# JAPAN

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JIS B 9960-32 (2004) (English): Safety of machinery -- Electrical equipment of machines -- Part 32: Requirements for hoisting machines

安 *The citizens of a nation must honor the laws of the land.* 倂

Fukuzawa Yukichi

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JIS

JAPANESE
INDUSTRIAL
STANDARD

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Japanese Standards Association

# JIS B 9960-32 : 2004

(JMF)

# Safety of machinery—Electrical equipment of machines—Part 32 : Requirements for hoisting machines

ICS 29.020; 53.020.01

**Reference number : JIS B 9960-32 : 2004 (E)**

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## Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Health, Labour and Welfare, and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Japan Machinery Federation (JMF), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **IEC 60204-32** : 1998 *Safety of machinery—Electrical equipment of machines—Part 32 : Requirements for hoisting machines* for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

**JIS B 9960** consists of the following parts under the general title *Safety of machinery—Electrical equipment of machines.*

*Part 1 : General requirements*

*Part 11 : Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

*Part 31 : Particular safety and EMC requirements for sewing machines, units and systems*

*Part 32 : Requirements for hoisting machines*

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# Safety of machinery— Electrical equipment of machines— Part 32 : Requirements for hoisting machines

**Introduction** This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60204-32** *Safety of machinery—Electrical equipment of machines—Part 32 : Requirements for hoisting machines* published in 1998 with modifying some technical contents.

Portions sidelined or underlined with dots are the matters modified from the original International Standard. The list of modification with its explanation is given in annex 1 (informative).

This Standard provides requirements and recommendations relating to the electrical equipment of hoisting machines so as to promote the following matters:

— Safety of persons and property

— Consisting of control response

— Ease of maintenance

High performance is not to be obtained at the expense of the essential factors mentioned above.

Figures 1 and 2 have been provided as an aid to understand the interrelationship of the various elements of a hoisting machine and associated equipment. Figure 1 is an overall block diagram of a typical material handling system (a group of cranes working together in a co-ordinated manner) and figure 2 is a block diagram of a typical crane and associated equipment.

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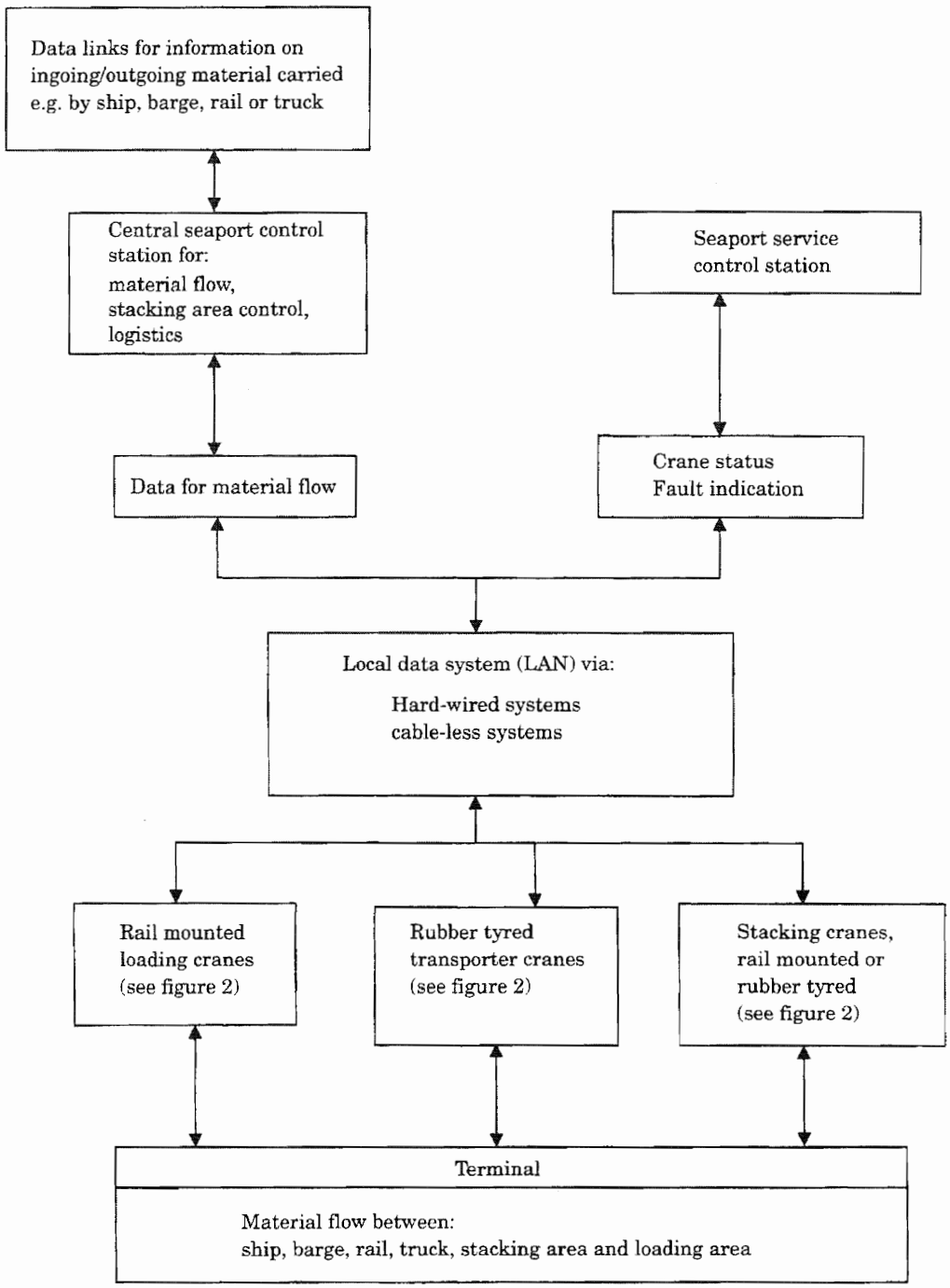


**Figure 1 Block diagram of combined working cranes in a typical material handling system in a seaport**

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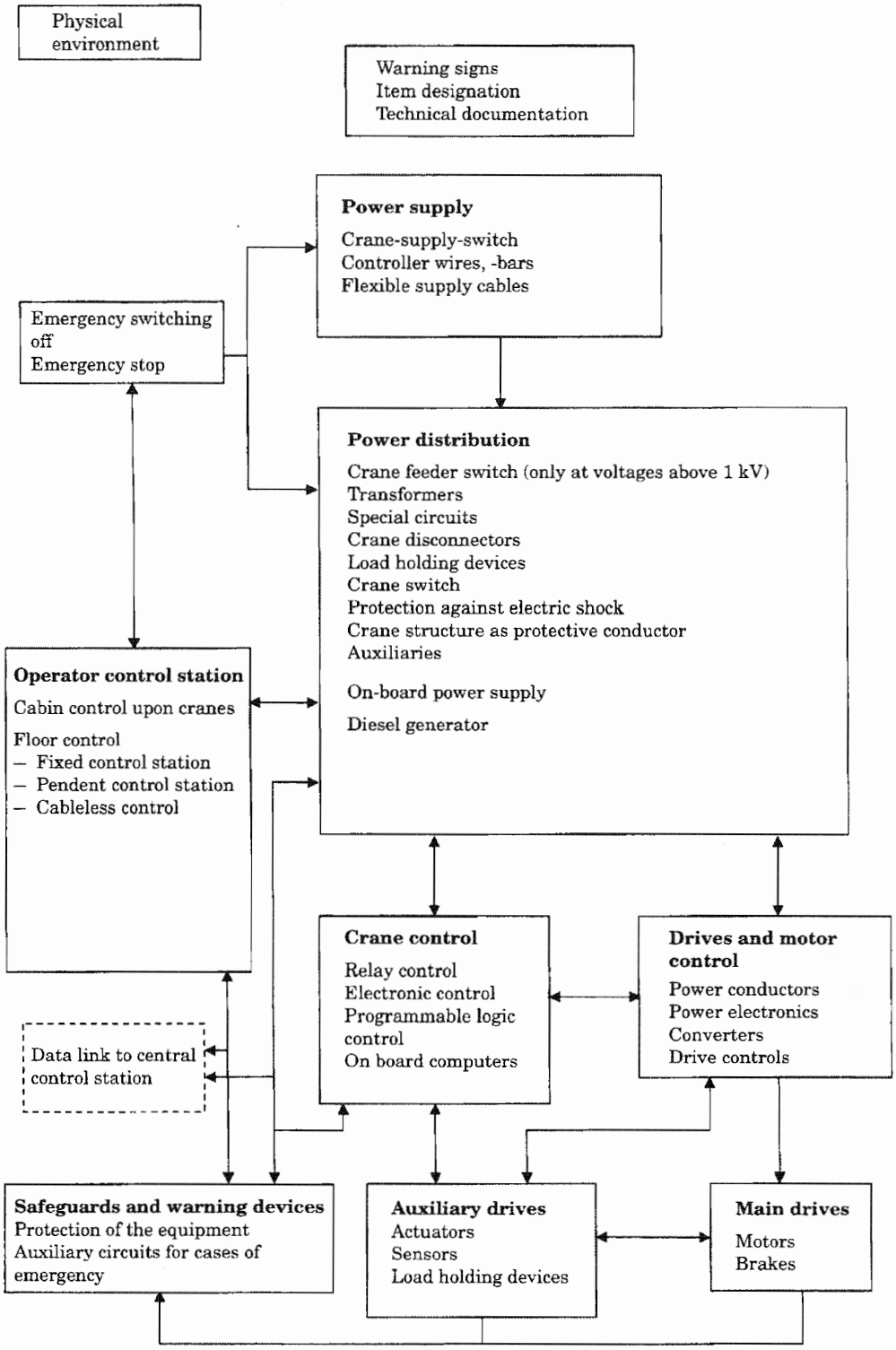


**Figure 2 Block diagram of a typical crane and its associated electrical equipment**

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**1 Scope** This part of **JIS B 9960** applies to the application of electrical and electronic equipment and systems to hoisting machines and related equipment.

NOTES 1 In this Standard, the term "electrical" includes both electrical and electronic matters (i.e. electrical equipment means both the electrical and the electronic equipment).

2 In the context of this part, the term "person" refers to any individual and includes those persons who are assigned and instructed by the user or his agent(s) in the use and care of the hoisting machine in question.

The equipment covered by this Standard commences at the point of connection of the supply to the electrical equipment of the hoisting machine (crane-supply-switch) including systems for power supply and control feeders situated outside of the hoisting machine, e.g. flexible cables or collector wires or collector bars (see figure 3).

NOTE 3 For the requirements for the electrical supply installation in buildings, see the series of **JIS C 0364**.

This Standard is applicable to equipment or parts of equipment not exceeding 1 000 V a.c. or 1 500 V d.c. between lines, and with nominal frequencies not exceeding 200 Hz.

NOTE 4 For the requirements for high voltage equipment exceeding 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV, see **JIS B 9960-11**.

Additional and special requirements can apply to the electrical equipment of hoisting machines that are used in potentially explosive and/or flammable atmospheres.

For the purposes of this Standard, hoisting machines include cranes of all types, winches of all types, and storage and retrieval machines. The following product groups are included:

— overhead travelling cranes;
— mobile cranes;
— tower cranes;
— slewing luffing cranes;
— gantry cranes;
— offshore cranes;
— floating cranes;
— winches of all types;
— hoists and accessories;
— loader cranes;
— container cranes
— cable cranes;
— load holding devices;
— storage and retrieval machines;
— monorail hoists;
— straddle carriers;
— rubber tyred gantry cranes (RTGs).

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This part of **JIS B 9960** does not cover individual items of electrical equipment other than their selection for use and their erection.

NOTE 5 The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

IEC 60204-32 : 1998 *Safety of machinery—Electrical equipment of machines—Part 32 : Requirements for hoisting machines* (MOD)

**2 Normative references** The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect or the year of publication is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply.

JIS B 3501 : 1997 *Programmable controllers—General information*

NOTE : **IEC 61131-1** : 1992 *Programmable controllers—Part 1 : General information* is equivalent to the said standard.

JIS B 3502 : 1997 *Programmable controllers—Equipment requirements and tests*

NOTE : **IEC 61131-2** : 1992 *Programmable controllers—Part 2 : Equipment requirements and tests* is equivalent to the said standard.

JIS B 6015 : 1996 *Machine tools—Electrical equipment—General requirements*

JIS B 9707 : 2002 *Safety of machinery—Safety distances to prevent danger zones being reached by the upper limbs*

NOTE : **ISO 13852** : 1996 *Safety of machinery—Safety distances to prevent danger zones being reached by the upper limbs* is identical with the said standard.

JIS C 0364-3 : 1999 *Electrical installations of buildings Part 3 : Assessment of general characteristics*

NOTE : **IEC 60364-3** : 1993 *Electrical installations of buildings—Part 3 : Assessment of general characteristics* is identical with the said standard.

JIS C 0364-4-41 : 1997 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 41 : Protection against electric shock*

NOTE : **IEC 60364-4-41** : 1992 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 41 : Protection against electric shock* is identical with the said standard.

JIS C 0364-4-46 : 1999 *Electrical installations of buildings Part 4 : Protection for safety Chapter 46 : Isolation and switching*

NOTE : **IEC 60364-4-46** : 1981 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 46 : Isolation and switching* is identical with the said standard.

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JIS C 0364-4-47 : 1999 *Electrical installations of buildings Part 4 : Protection for safety Chapter 47 : Application of protective measures for safety Section 470 : General Section 471 : Measures of protection against electric shock*

NOTE : **IEC 60364-4-47** : 1981 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 47 : Application of protective measures for safety—Section 470 : General—Section 471 : Measures of protection against electric shock* is identical with the said standard.

JIS C 0364-4-473 : 1999 *Electrical installations of buildings Part 4 : Protection for safety Chapter 47 : Application of protective measures for safety Section 473 : Measures of protection against overcurrent*

NOTE : **IEC 60364-4-473** : 1995 *Electrical installations of buildings—Part 4 : Protector for safety—Chapter 47 : Application of protective measures for safety—Section 473 : Measures of protection against overcurrent* is identical with the said standard.

JIS C 0364-4-481 : 1999 *Electrical installations of buildings Part 4 : Protection for safety Chapter 48 : Choice of protective measures as a function of external influences Section 481 : Selection of measures for protection against electric shock in relation to external influences*

NOTE : **IEC 60364-4-481** : 1993 *Electrical installations of buildings—Part 4 : Protection for safety—Chapter 48 : Choice of protective measures as a function of external influences—Section 481 : Selection of measures for protection against electric shock in relation to external influences* is identical with the said standard.

JIS C 0364-5-54 : 1997 *Electrical installations of buildings Part 5 : Selection and erection of electrical equipment Chapter 54 : Earthing arrangements and protective conductors*

NOTE : **IEC 60364-5-54** : 1980 *Electrical installations of buildings—Part 5 : Selection and erection of electrical equipment—Chapter 54 : Earthing arrangements and protective conductors* is identical with the said standard.

JIS C 0364-5-523 : 1999 *Electrical installations of buildings—Part 5 : Selection and erection of electrical equipment—Section 523 : Current-carrying capacities in wiring systems*

NOTE : **IEC 60364-5-523** : 1983 *Electrical installations of buildings—Part 5 : Selection and erection of electrical equipment—Chapter 52 : Wiring systems—Section 523 : Current-carrying capacities* is identical with the said standard.

JIS C 0364-6-61 : 1999 *Electrical installations of buildings Part 6 : Verification Chapter 61 : Initial verification*

NOTE : **IEC 60364-6-61** : 1986 *Electrical installations of buildings—Part 6 : Verification—Chapter 61 : Initial verification* is identical with the said standard.

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JIS C 0445 : 1999 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE : **IEC 60445** : 1988 *Identification of equipment terminals and of terminations of certain designated conductors including general rules of an alphanumeric system* is identical with the said standard.

JIS C 0446 : 1999 *Identification of conductors by colours or numerals*

NOTE : **IEC 60446** : 1989 *Identification of conductors by colours or numerals* is equivalent to the said standard.

JIS C 0447 : 1997 *Man-machine interface (MMI)—Actuating principles*

NOTE : **IEC 60447** : 1993 *Man-machine interface (MMI)—Actuating principles* is identical with the said standard.

JIS C 0448 : 1997 *Coding of indicating devices and actuators by colours and supplementary means*

NOTE : **IEC 60073** : 1996 *Basic and safety principles for man-machine interface, marking and identification—Coding principles for indication devices and actuators* is identical with the said standard.

JIS C 0617 *Graphical symbols for diagrams*

NOTE : **IEC 60617** *Graphical symbols for diagrams* is equivalent to the said standard.

JIS C 0704 : 1995 *Insulation test for control gear*

NOTE : **IEC 60664-1** : 1992 *Insulation coordination for equipment within low-voltage systems—Part 1 : Principles, requirements and tests* is equivalent to the said standard.

JIS C 0920 : 1993 *Degrees of protection provided by enclosures (IP Code)*

NOTE : **IEC 60529** : 1989 *Degrees of protection provided by enclosures (IP Code)* is equivalent to the said standard.

JIS C 1082-1 : 1999 *Preparation of documents used in electrotechnology—Part 1 : General requirements*

NOTE : **IEC 61082-1** : 1991 *Preparation of documents used in electrotechnology—Part 1 : General requirements* is equivalent to the said standard.

JIS C 1082-2 : 1999 *Preparation of documents used in electrotechnology—Part 2 : Function-oriented diagrams*

NOTE : **IEC 61082-2** : 1993 *Preparation of documents used in electrotechnology—Part 2 : Function-oriented diagrams* is identical with the said standard.

JIS C 1082-3 : 1999 *Preparation of documents used in electrotechnology—Part 3 : Connection diagrams, tables and lists*

NOTE : **IEC 61082-3** : 1993 *Preparation of documents used in electrotechnology—Part 3 : Connection diagrams, tables and lists* is identical with the said standard.

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JIS C 1082-4 : 1999 *Preparation of documents used in electrotechnology—Part 4 : Location and installation documents*

NOTE : **IEC 61082-4** : 1996 *Preparation of documents used in electrotechnology—Part 4 : Location and installation documents* is identical with the said standard.

JIS C 2811 : 1995 *Terminal blocks for industrial and similar use*

NOTE : **IEC 60947-7-1** : 1989 *Low-voltage switchgear and controlgear—Part 7 : Ancillary equipment—Section One—Terminal blocks for copper conductors* is equivalent to the said standard.

JIS C 3307 : 2000 *600 V Polyvinyl chloride insulated wires*

NOTE : **IEC 60228** : 1978 *Conductors of insulated cables* is identical with the said standard.

JIS C 3665-1 : 1998 *Tests on electric cables under fire conditions—Part 1 : Test on a single vertical insulated wire or cable*

NOTE : **IEC 60332-1** : 1993 *Tests on electric cables under fire conditions—Part 1 : Test on a single vertical insulated wire or cable* is identical with the said standard.

JIS C 4034-1 : 1999 *Rotating electrical machines Part 1 : Rating and performance*

NOTE : **IEC 60034-1** : 1996 *Rotating electrical machines—Part 1 : Rating and performance* is equivalent to the said standard.

JIS C 4034-5 : 1999 *Rotating electrical machines—Part 5 : Classification of degrees of protection provided by enclosures of rotating electrical machines (IP Code)*

NOTE : **IEC 60034-5** : 1991 *Rotating electrical machines—Part 5 : Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)* is identical with the said standard.

JIS C 8201-2 : 1999 *Low-voltage switchgear and controlgear—Part 2 : Circuit breaker*

NOTE : **IEC 60947-2** : 1995 *Low-voltage switchgear and controlgear—Part 2 : Circuit-breakers* is equivalent to the said standard.

JIS C 8201-3 : 2001 *Low-voltage switchgear and controlgear—Part 3 : Switches, disconnectors, switch-disconnectors and fuse-combination units*

NOTE : **IEC 60947-3** : 1990 *Low-voltage switchgear and controlgear—Part 3 : Switches, disconnectors, switch-disconnectors, and fuse combination units* is equivalent to the said standard.

JIS C 8201-4-1 : 1999 *Low-voltage switchgear and controlgear—Part 4 : Contactors and motor-starters, Section 1 : Electromechanical contactors and motor-starters*

NOTE : **IEC 60947-4-1** : 1990 *Low-voltage switchgear and controlgear—Part 4 : Contactors and motor-starters—Section One : Electromechanical contactors and motor-starters* is equivalent to the said standard.

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JIS C 8201-5-1 : 1999 *Low-voltage switchgear and controlgear—Part 5-1 : Control circuit devices and switching elements—Electromechanical control circuit devices*

NOTE : **IEC 60947-5-1** : 1997 *Low-voltage switchgear and controlgear—Part 5-1 : Control circuit devices and switching elements—Electromechanical circuit devices* is equivalent to the said standard.

JIS C 8285-1 : 2000 *Plugs, socket-outlets and couplers for industrial purposes—Part 1 : General requirements*

NOTE : **IEC 60309-1** : 1988 *Plugs, socket-outlets and couplers for industrial purposes—Part 1 : General requirements* is equivalent to the said standard.

JIS C 8370 : 1996 *Molded case circuit breakers (MCCB)*

JIS C 8371 : 1992 *Residual current operated circuit breakers*

JIS C 8372 : 1991 *Low-voltage circuit breakers*

JIS C 8480 : 1998 *Box-type switchgear assemblies for low-voltage distribution purpose*

NOTE : **IEC 60439-1** : 1992 *Low-voltage switchgear and controlgear assemblies—Part 1 : Type-tested and partially type-tested assemblies* is equivalent to the said standard.

JIS C 9742 : 2000 *Isolating transformers and safety isolating transformers—Requirements*

NOTE : **IEC 60742** : 1983 *Isolating transformers and safety isolating transformers—Requirements* is equivalent to the said standard.

JIS Z 9101 : 1995 *Safety colours and safety signs*

NOTE : **ISO 3864** : 1984 *Safety colours and safety signs* is equivalent to the said standard.

ISO 7000 : 1989 *Graphical symbols for use on equipment—Index and synopsis*

ISO 12100-1 : 2003 *Safety of machinery—Basic concepts, general principles for design—Part 1 : Basic terminology, methodology*

IEC 60034-11 : 1978 *Rotating electrical machines. Part 11 : Built-in thermal protection*

IEC 60050 (191) : 1990 *International Electrotechnical Vocabulary. Chapter 191 : Dependability and quality of service*

IEC 60050 (441) : 1984 *International Electrotechnical Vocabulary. Chapter 441 : Switchgear, controlgear and fuses*

IEC 60050 (826) : 1982 *International Electrotechnical Vocabulary. Chapter 826 : Electrical installations of buildings*

IEC 60072-1 : 1991 *Dimensions and output series for rotating electrical machines—Part 1 : Frame numbers 56 to 400 and flange numbers 55 to 1080*

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IEC 60072-2 : 1990 *Dimensions and output series for rotating electrical machines—Part 2 : Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60076-5 : 1976 *Power transformers—Part 5 : Ability to withstand short-circuit*

IEC 60146 *General requirements and line commutated convertors*

IEC 60417-2 : 1998 *Graphical symbols for use on equipment—Part 2 : Symbol originals*

IEC 60621-3 : 1979 *Electrical installations for outdoor sites under heavy conditions (including open-cast mines and quarries). Part 3 : General requirements for equipment and ancillaries*

IEC 60757 : 1983 *Code for designation of colours*

IEC 61140 : 2001 *Protection against electric shock—Common aspects for installation and equipment*

IEC 61346-1 : 1996 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations—Part 1 : Basic rules*

**3 Definitions** For the purpose of this part of **JIS B 9960**, the following definitions apply.

**3.1 actuator** The part of the actuating system to which an external actuating force is applied [see **IEC 60050-(441)**, **15-22**].

NOTES 1 The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

2 There are some actuating means that do not require an external actuating force but only an action.

3 See also **3.38**.

**3.2 ambient temperature** The temperature of the air or other medium where the equipment is to be used [see **IEC 60050-(826)**, **01-04**].

**3.3 barrier** A part providing protection against direct contact from any usual direction of access [see **IEC 60050-(826)**, **03-13**].

**3.4 cabin controlled hoisting machine** A hoisting machine operated from a cabin permanently attached to the hoisting machine.

**3.5 cable tray** A cable support consisting of a continuous base and raised edges and no covering [see **IEC 60050-(826)**, **06-07**].

NOTE : A cable tray may be perforated or non perforated.

**3.6 cable trunking system** A system of closed enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables and cords, and for the accommodation of other electrical equipment [see **IEC 60050-(826)**, **06-04**].

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**3.7 concurrent** Acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily synchronously).

**3.8 conduit** A part of a closed wiring system of circular or non-circular cross-section for insulated conductors and/or cables in electrical installations, allowing them to be drawn in and/or replaced [see **IEC 60050-(826), 06-03**].

NOTE : Conduits should be sufficiently close-jointed so that the insulated conductors and/or cables can only be drawn in and not inserted laterally.

**3.9 control circuit (of a hoisting machine)** A circuit used for the operational control of the hoisting machine and for protection of the power circuits.

**3.10 control device** A device connected into the control circuit or (electric) power circuit and used for controlling the operation of the hoisting machine (e.g. inverter, converter, position sensor, manual control switch, relay and magnetically operated valve).

**3.11 controlgear** A general term covering switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structure [see **IEC 60050-(441), 11-03**].

**3.12 controlled stop** The stopping of a hoisting machine motion by, for example, reducing the electrical command signal to zero once the stop signal has been recognized by the control but retaining electrical power to the hoisting machine actuators during the stopping process.

**3.13 crane** A machine for hoisting/lowering and horizontally relocating suspended loads.

**3.14 crane-disconnector** A hand-operated disconnecting device installed on a hoisting machine for disconnecting (isolating) a supply circuit (e.g. for repair or maintenance work).

**3.15 crane-switch** A switching device designed to break the electrical power supply to the connected drives (e.g. for use in cases of emergency stop).

**3.16 crane-supply-switch** A disconnecting (isolating) and switching device used to disconnect the hoisting machine from the incoming supply.

**3.17 digital** Operated by the use of discrete signals to represent data in the form of numbers or other characters.

**3.18 direct contact** Contact of persons or livestock with live parts [see **IEC 60050-(826), 03-05**].

**3.19 duct** An enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars.

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NOTE : Conduits (see **3.8**), cable trunking systems (see **3.6**) and underfloor channels are types of duct.

**3.20 electrical operating area** A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs.

**3.21 electronic equipment** That part of the electrical equipment containing circuitry mainly based on electronic devices and components.

**3.22 enclosed electrical operating area** A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs.

**3.23 enclosure** A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact [see **IEC 60050-(826), 03-12**].

NOTE : The definition taken from the existing **IEV** needs the following explanations under the scope of this Standard (see **JIS C 0920, 3.1**).

a) enclosures provide protection of persons or livestock against access to hazardous parts;

b) barriers, shaped openings, or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure, except where they can be removed without the use of a key or tool.

An enclosure may also include the followings:

— a cabinet or box, either mounted on the hoisting machine or separate from the hoisting machine;

— a compartment consisting of an enclosed space within the hoisting machine structure (e.g. box girder).

**3.24 equipment** A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation.

**3.25 equipotential bonding** Electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential [see **IEC 60050-(826), 04-09**].

**3.26 exposed conductive part** A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions [see **IEC 60050-(826), 03-02**].

NOTE : A conductive part of electrical equipment which can only become live under fault conditions through an exposed conductive part, is not considered to be an exposed conductive part.

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**3.27 extraneous conductive part** A conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential [see **IEC 60050-(826), 03-03**].

**3.28 failure** The termination of the ability of an item to perform a required function.

NOTES 1 After failure the item has a fault.

2 "Failure" is an event, as distinguished from "fault", which is a state.

3 This concept as defined does not apply to items consisting of software only [see **IEC 60050-(191), 04-01**].

4 In practice the terms fault and failure are often used synonymously.

**3.29 fault** The state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources [see **IEC 60050-(191), 05-01**].

NOTE : A fault is often the result of a failure of the item itself, but may exist without prior failure.

**3.30 guard** Part of a hoisting machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard, etc. (see **ISO 12100-1, 3.22.1**).

**3.31 hand-held direct-control device** A manually-operated switching device, the enclosure of which is portable by hand during operation, acting directly on a power circuit.

**3.32 hazard** A source of possible injury or damage to health (see **ISO 12100-1, 3.5**).

**3.33 indirect contact** Contact of persons or livestock with exposed conductive parts which have become live under fault conditions [see **IEC 60050-(826), 03-06**].

**3.34 (electrically) instructed person** A person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create [see **IEC 60050-(826), 09-02**].

**3.35 interlock (for safeguarding)** An arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the electrical energy distributed to the hoisting machine.

**3.36 limiting device** A device which prevents a hoisting machine or a hoisting machine element from exceeding a designed limit (e.g. space limit, pressure limit) (see **ISO 12100-1, 3.23.7**).

**3.37 live part** A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor (conductor having both functions of neutral point and protective conductor) [see **IEC 60050-(826), 03-01**].

NOTE : This term does not necessarily imply a risk of electric shock.

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**3.38 machine actuator** A power mechanism used to effect motion of any hoisting machine drive.

**3.39 machinery (machine)** An assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, etc., joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material.

The term "machinery" also covers an assembly of machines which, in order to achieve one and the same end, are arranged and controlled so that they function as an integral whole.

"Machinery" also means interchangeable equipment modifying the function of a machine, which is placed on the market (supplied) for the purpose of being assembled with a machine or a series of different machines, or with a tractor by the operator himself insofar as this equipment is not a spare part or tool.

**3.40 marking** Signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device.

**3.41 neutral conductor (symbol N)** A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy [see **IEC 60050-(826), 01-03**].

**3.42 obstacle** A part preventing unintentional direct contact, but not preventing direct contact by deliberate action [see **IEC 60050-(826), 03-14**].

**3.43 overcurrent** Any current exceeding the rated value. For conductors, the rated value is the current-carrying capacity [see **IEC 60050-(826), 05-06**].

**3.44 overload (of a circuit)** The time/current relationship in a circuit which is in excess of the rated full load of the circuit when the circuit is not under a fault condition.

NOTES 1 Overload should not be used as a synonym for overcurrent.

2 In hoisting machines the term "overload" is also used for mechanical overload, which may or may not cause an electrical overload.

**3.45 plug/socket combination** A plug and socket-outlet, a cable coupler, or an appliance coupler, in accordance with **JIS C 8285-1**.

**3.46 positive (or direct) opening action (of a contact element)** The achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs) (see **JIS C 8201-5-1, 3.22**).

**3.47 power circuit** A circuit used for supplying power from the supply network to units of equipment used for productive operation and to transformers supplying control circuits.

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**3.48 protective bonding circuit** The whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure.

**3.49 protective conductor (symbol PE)** A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts [see **IEC 60050-(826), 04-05**]:

— exposed conductive parts;

— extraneous conductive parts;

— main earthing terminal;

— earth electrode;

— earthed point of the source or artificial neutral.

**3.50 redundancy** The application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function another is available to perform that function.

**3.51 reference designation** A distinctive code which serves to identify an item in a diagram, list, chart, and on the equipment.

**3.52 risk** A combination of the probability and the degree of possible injury or damage to health in a hazardous situation (see **ISO 12100-1**).

**3.53 safe working procedure** A method of working that reduces risk.

**3.54 safeguard** A guard or protective device used as a means to protect persons from a present or impending hazard.

**3.55 safeguarding** Safety measures consisting of the use of specific means called "safeguards" to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design.

**3.56 servicing level** Level on which persons normally stand when operating or maintaining the electrical equipment.

**3.57 short circuit current** An overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit [see **IEC 60050-(441), 41-07**].

**3.58 (electrically) skilled person** A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create [see **IEC 60050-(826), 09-01**].

**3.59 standard hoisting machine** Hoisting machine which is catalogued by the supplier.

**3.60 supplier** An entity (e.g. manufacturer, contractor, installer, integrator) which provides equipment or services associated with the hoisting machine.

NOTE : The user may also act in the capacity of a supplier to himself.

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**3.61 switching device** A device designed to make or break the current in one or more electric circuits [see **IEC 60050-(441), 14-01**].

NOTE : A switching device may perform one or both of these actions.

**3.62 terminal** A conductive part of a device provided for electrical connection to external circuits.

**3.63 uncontrolled stop** The stopping of hoisting machine motion by removing power to the machine actuators, all brakes and/or other mechanical stopping devices being activated.

**3.64 user** An entity which utilizes the hoisting machine and its associated electrical equipment.

## 4 General requirements

**4.1 General considerations** This part of **JIS B 9960** is intended to apply to electrical equipment used with a hoisting machine and with a group of hoisting machines working together in a co-ordinated manner. The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the hoisting machine. This will determine the acceptable level of risk, and the necessary protective measures for persons who can be exposed to those hazards, while still maintaining an acceptance level of performance of the hoisting machine and its equipment.

Hazards can result from, but are not limited to, the following causes:

— failures or faults in the electrical equipment resulting in the possibility of electric shock or electrical fire;

— failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the hoisting machine;

— disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the hoisting machine;

— loss of continuity of circuits that depend upon sliding or rolling contacts, resulting in a failure of a safety function;

— electrical disturbances (e.g. electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated;

— stored energy (either electrical or mechanical);

— audible noise at levels that cause health problems to persons.

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user. Design and development shall be the first consideration in the reduction of risks. Where this is not sufficient, safeguarding and safe working procedures shall be considered. Safeguarding includes the use of safeguards and awareness means.

The use of the inquiry form as shown in annex A (informative) is recommended in order to facilitate an appropriate agreement between the user and the supplier(s) on basic conditions and additional user requirements related to the electrical equipment.

Those additional requirements are to:

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— provide additional features that are dependent on the type of hoisting machine (or group of hoisting machines) and the application;

— facilitate maintenance and repair; and

— advance the reliability and ease of operation.

NOTE : The use of annex A is not applicable in the case of standard hoisting machines. The relevant information for the user is given in the supplier's catalogue.

### 4.2 Selection of equipment

**4.2.1 General** Electrical components and devices shall be suitable for their intended use and shall conform to relevant **JIS** or **IEC** standards where such exist.

**4.2.2 Selection of power contactors** The contactors with their associated short circuit protective devices shall have type "2" co-ordination in accordance with **JIS C 8201-4-1**, **7.2.5.1**.

Contactors which perform the stopping function of motion drives, initiated by safety-related control circuits, shall be selected and arranged with other equipment in such a way that contact welding either will not occur or will not prevent the emergency stop function. The supplier's recommendations should be followed (see also **7.2.9**).

NOTE : Contactors directly controlling motions and demanding a great number of contactor operations should have a mechanical life of at least 3 million operating cycles. (See annex A, item **30** and **JIS C 8201-4-1**, **2.2.23**).

### 4.3 Electrical supply

**4.3.1 General** The electrical equipment shall be designed to operate correctly with any of the following conditions of the supply at the point of supply (i.e. at the crane-supply-switch, as shown in figure 3):

— as specified in **4.3.2** or **4.3.3**; or

— as otherwise specified by the user (see annex A); or

— as specified by the supplier in the case of a special source of supply such as an on-board generator in **4.3.4**.

**4.3.2 AC supplies**

| | |
|---|---|
| Voltage | Steady state voltage: 0.9 ... 1.1 of nominal voltage |
| | NOTE : For certain applications (e.g. large container cranes), and by agreement with the user, the voltage range may be reduced to 0.95 ... 1.05 of nominal voltage at the point of supply (i.e. at the crane-supply-switch as shown in figure 3). |
| Frequency | 0.99 ... 1.01 of nominal frequency continuously; |
| | 0.98 ... 1.02 short time. |
| | NOTE : The short time value may be specified by the user (see annex A). |

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| | |
|---|---|
| Harmonics | Harmonic distortion not to exceed 10 % of the total r.m.s. voltage between live conductors for the sum of the second to fifth harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the sixth to 30th harmonic is permissible. |
| Voltage unbalance | Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies shall exceed 2 % of the positive sequence component. |
| Voltage interruption | Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions. |
| | NOTE : In some converter-drives with power feedback, voltage interruptions as short as 3 ms or less may cause conduction-through and fuse blowing. |
| Voltage dips | Voltage dips shall not exceed 20 % of the peak voltage of the supply for more than one cycle. There shall be more than 1 s between successive dips. |

### 4.3.3 DC supplies

**From batteries**:

| | |
|---|---|
| Voltage | 0.85 ... 1.15 of nominal voltage;<br>0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles. |
| Voltage interruption | Not exceeding 5 ms. |

**From converting equipment**:

| | |
|---|---|
| Voltage | 0.9 ... 1.1 of nominal voltage. |
| Voltage interruption | Not exceeding 20 ms. There shall be more than 1 s between successive interruptions. |
| Ripple (peak-to-peak) | Not exceeding 0.15 of nominal voltage. |

NOTE : This is a variation to **IEC Guide 106** to ensure proper operation of electronic equipment.

**4.3.4 On-board power supply** For special supply systems such as on-board generators, the limits given in **4.3.2** and **4.3.3** may be exceeded provided that the equipment is designed to operate correctly with those conditions. For AC power supply systems, means shall be provided to switch off the power supply automatically when:

— the supply voltage is not within 0.85 ... 1.1 of nominal voltage;

— the frequency is not within 0.95 ... 1.05 of nominal frequency.

## 4.4 Physical environment and operating conditions

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**4.4.1 General** The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in **4.4.2** to **4.4.8**. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see annex A).

**4.4.2 Electromagnetic compatibility (EMC)** The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended places of use. In addition, the equipment shall have an adequate level of immunity to electromagnetic disturbances so that it can operate correctly in its intended environment.

Information : **EN 50081** and **EN 50082-2** give general EMC emission and immunity limits. Those requirements are also under consideration by **IEC/TC 77** and **CISPR**.

NOTE : Product standards (e.g. **JIS C 8480** annex 2, **7.10**) may give more specific EMC requirements.

Generated disturbances can be limited by:

— suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors or active devices, or a combination of these components; or

— screening of the equipment in a bonded electrically conductive enclosure to provide segregation from other equipment.

Undesirable effects of electrostatic discharge, radiated electromagnetic energy and mains borne disturbances shall be avoided, for example by the use of appropriate filters and time delays, a choice of certain power levels, and the use of suitable wiring types and practices.

Measures that can be used to reduce the effects of disturbances on equipment include the following:

— connections of circuits to a reference potential: each circuit is connected to a terminal on a ground plane (chassis) (see figure 4) that is connected to earth using an insulated conductor of large cross-sectional area (e.g. a minimum area of 6 $mm^2$ of type class 6 in accordance with annex B table 4).

— interconnections of conductive structural parts of the equipment: conductive structural parts are connected to a common point using conductors (e.g. a copper plate) of large cross-sectional area that are as short as is possible. Conductive parts connected to the equipment enclosure via sliding contacts or hinges are also connected to that enclosure using large section braided conductors (see also **8.3.3** and figure 4);

— wiring practices: using electrostatic screens, electromagnetic shields, twisted conductors, and cable orientation (i.e. crossing cable runs at as near to 90° as is practicable), or running the conductors parallel to and as close as is practicable to the ground-plane, to minimize the disturbances from power cables to low level control wiring.

— separation of equipment: separating and/or shielding sensitive equipment (e.g. units working with pulses and/or at low signal levels) from switching equipment (e.g. electromagnetic relays, thyristors): separating low level signal wiring from control and power cables.

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**4.4.3 Ambient air temperature** Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation between air temperatures of 0 °C and +40 °C. For very hot environments (e.g. hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary (see annex A).

**4.4.4 Humidity** The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities may be permitted at lower temperature (e.g. 90 % at 20 °C).

Harmful effects of occasional condensation shall be avoided by proper design of the equipment or, where necessary, by proper additional measures (e.g. built-in heaters, air conditioners, drain holes).

**4.4.5 Altitude** Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m above mean sea level.

**4.4.6 Contaminants** Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids (see **12.3**).

Consideration should be given to the suitability of the electrical equipment where contaminants (e.g. dust, acids, corrosive gases, salt) are present in the physical environment in which the electrical equipment is to be installed (see annex A).

**4.4.7 Ionizing and non-ionizing radiation** When equipment is subject to radiation (e.g. microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement may be necessary between the supplier and the user (see annex A).

**4.4.8 Vibration, shock, and bump** Undesirable effects of vibration, shock and bump (including those generated by the hoisting machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from sources of vibration, or by the use of antivibration mountings. A special agreement may be necessary between the supplier and the user (see annex A).

**4.5 Transportation and storage** Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of −25 °C to +55 °C, and for short periods not exceeding 24 h at up to +70 °C. Suitable means shall be provided to prevent damage from humidity, vibration, and shock.

NOTE : Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

**4.6 Provisions for handling** Heavy and bulky electrical equipment that has to be removed from the hoisting machine for transport, or that is independent of the hoisting machine, shall be provided with suitable means for handling by cranes or similar equipment (see also **14.4.6**).

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**4.7 Installation and operation** Electrical equipment shall be installed and operated in accordance with the supplier's instructions, and ergonomic principles should be taken into account.

## 5 Incoming supply conductor terminations and devices for disconnecting and switching off

**5.1 Incoming supply conductor terminations** It is recommended that, the electrical equipment of a hoisting machine should be connected to a single power supply. Where it is necessary to use another supply for certain parts of the equipment (e.g. electronic circuits, electromagnetic clutches), that supply should be derived, as far as is possible, from devices (e.g. transformers, converters) forming part of the electrical equipment of the hoisting machine. For large complex hoisting machines, there may be a need for more than one incoming supply (see **5.3.5.1**).

Unless a plug is provided with the hoisting machine for the connection to the supply (see **5.3.2**), it is recommended that the supply conductors are terminated at the crane-supply-switch. When that is not practicable, separate terminations shall be provided. Where a neutral conductor is used, it shall be clearly indicated in the technical documentation of the hoisting machine, such as in the installation diagram and in the circuit diagram, and a separate insulated terminal, labelled N, shall be provided for the neutral conductor (see also annex A).

There shall be no connection between the neutral conductor and the protective bonding circuit inside the electrical equipment, nor shall a combined PEN terminal be used. Excepting that TN-C-S systems may be used in the case of certain complex hoisting machines, provided they are in accordance with **13.8.2** and **JIS C 0364-3**, **312.2**, figure 31B.

All terminals for the incoming supply connection shall be clearly identified in accordance with **JIS C 0445**. For the identification of the external protective conductor terminal, see **5.2**.

**5.2 Terminal for connection to the external protective earthing system** For each incoming supply, a terminal shall be provided in the vicinity of the associated phase conductor terminals (see **8.2.1**) for connection of the hoisting machine to the external protective earthing system or to the external protective conductor, depending upon the supply distribution system, and in accordance with the relevant installation standards.

The terminal shall be of such a size as to enable the connection of an external protective copper conductor with a cross-sectional area in accordance with table 1.

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**Table 1 Minimum cross-sectional area of the external protective copper conductor to determine the terminal size**

| Cross-sectional area of phase conductors supplying the equipment<br>$S$<br>mm² | Minimum cross-sectional area of the external protective copper conductor<br>$S_p$<br>mm² |
|---|---|
| $S \leqq 16$ | $S$ |
| $16 < S \leqq 35$ | 16 |
| $S > 35$ | $S/2$ |

Where an external protective conductor of a material other than copper is used, the terminal size shall be selected accordingly (see also **8.2.2**).

At each incoming supply point, the terminal for the external protective conductor shall be identified by marking with the letters PE (see **JIS C 0445**), in order to avoid confusion at the point(s) of connection between hoisting machine and fixed installation.

The other terminals used for the connection of hoisting machine components or subassemblies to the protective bonding circuit of the hoisting machine shall be identified either by the graphic symbol **IEC 60417-2-5019** or with the letters PE (the graphical symbol being preferred), or by use of the bicolour combination GREEN-AND-YELLOW.

Graphical symbol by **IEC 60417-2-5019**

### 5.3 Supply disconnecting (isolating) and switching devices

**5.3.1 General** The functions of supply disconnection and/or switching are performed by the following devices:

— crane-supply-switch (see **5.3.5**);

— crane-disconnector (see **5.3.6**);

— crane-switch (see **5.3.7**).

(see also figure 3)

**5.3.2 Type** The supply disconnecting and switching devices can be one of the following types:

a) a switch-disconnector, with or without fuses, in accordance with **JIS C 8201-3** table 12, utilization category AC-23B or DC-23B (see also **JIS C 8201-3**, **8.3.5**);

b) a disconnector, with or without fuses, in accordance with **JIS C 8201-3**, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;

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c) a circuit breaker with the disconnection (isolation) function as specified in **JIS C 8201-2** and in accordance with **JIS C 8370**, **JIS C 8371**, **JIS C 8372** or **JIS C 8201-2**.

d) a plug/socket combination for a hoisting machine with a rated current not exceeding 16 A and a total power rating not exceeding 3 kW;

e) a plug and socket-outlet or an appliance coupler (see **3.45**) for a flexible cable supply (e.g. reeled, festooned) to a hoisting machine under the following conditions:

— it shall not be possible to connect or disconnect a plug and socket-outlet or an appliance coupler, without breaking capacity, during load conditions;

— the plug and socket-outlet or the appliance coupler shall be so connected that the part connected to the incoming supply is that which is protected to at least IP2X or IPXXB.

Where a plug/socket combination with breaking capacity is used as a crane-supply-switch, the requirements of **5.3.5.3** shall apply (see also **14.4.5**).

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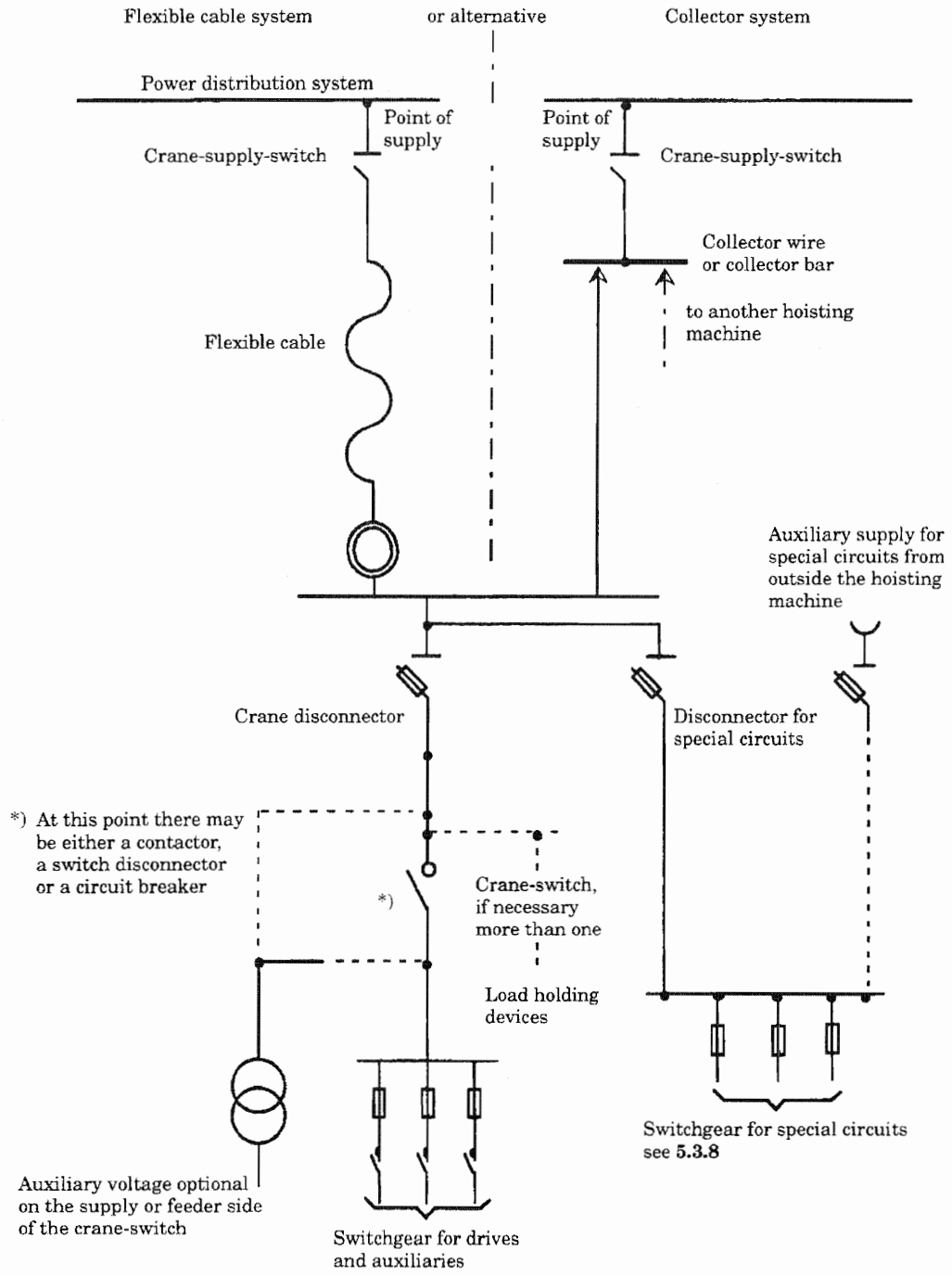


**Figure 3 Examples of electrical supply systems**

**5.3.3 Requirements** When a supply disconnecting and switching device is one of the first three types specified in **5.3.2** (i.e. a switch-disconnector, a disconnector used in combination with switching devices, or a circuit-breaker), it shall fulfil all of the following requirements:

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— isolate the electrical equipment from the supply and have one OFF (isolated) and one ON position only, clearly marked with "O" and "I" (symbols **IEC 60417-2, 5008** and **5007**, see also **10.2.2**), with the actuating directions in accordance with **JIS C 0447**. Circuit-breakers that, in addition, have a reset (tripped) position between "O" and "I" are also deemed to satisfy this requirement;

— have a visible gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and there is an adequate isolating distance between all the contacts in accordance with **JIS C 8201-3**.

— have an external operating means (e.g. handle), (**exception:** power operated switchgear need not be operable from outside the enclosure when there are other means to open it). The handle should be BLACK or GREY (**exception:** see **10.7.4**);

— be provided with a means permitting it to be locked in the OFF (isolated) position (e.g. by padlocks). When so locked, remote as well as local closing shall be prevented;

— disconnect all live conductors of its power supply circuit. However, for TN supply systems, the neutral conductor may or may not be disconnected. It is noted that in some countries, disconnection of the neutral conductor (when used) is compulsory;

— have a breaking capacity sufficient to interrupt the current of the largest motor when stalled, together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor.

**5.3.4 Operating handle** The handle of a supply disconnecting and switching device shall be easily accessible and located between 0.6 m and 1.9 m above the servicing level. An upper limit of 1.7 m is recommended.

**5.3.5 Crane-supply-switch**

NOTE : This subclause does not apply to hoisting machines having on-board power-supplies and without an alternative power-supply from the outside.

**5.3.5.1 General** Crane-supply-switches shall be provided:

— for disconnecting (isolating) the collector wires or collector bars or cables to which the hoisting machine(s) is connected from the incoming supply for repair and maintenance works.

— where required, for emergency stop and/or emergency switching off (see **9.2.5.4**).

Where two or more incoming supplies are used, a crane-supply-switch shall be provided for each supply, together with protective interlocks to ensure their correct operation. The requirements of **5.6** shall apply as appropriate to crane-supply-switches.

**5.3.5.2 Type** The crane-supply-switch shall be one of the types specified in **5.3.2**.

In the case of hoisting machines on building sites, equipment on the site distribution board may be used to achieve the function of the crane-supply-switch. The requirement of **5.6** shall be fulfilled by locking regardless of whether or not the disconnecting means is under immediate supervision.

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**5.3.5.3 Requirements** In the case of a single hoisting machine, the breaking capacity shall be sufficient to switch off the sum of the maximum current in locked rotor condition of the largest drive and the normal running currents of the other drives that can be operating at the same time.

NOTE : If there is more than one hoisting machine on one common power supply according to the given service conditions, a proven diversity factor may be used.

If the crane-supply-switch performs the emergency switching off function according to **9.2.5.4.3**, it shall be capable of being opened (remotely or directly) from an easily accessible place(s) close to the hoisting machine.

The reconnection of a crane-supply-switch that has been remotely operated by an emergency switching off device shall only be possible after the resetting of the emergency switching off device(s).

Where a collector wire or collector bar is fed by several crane-supply-switches connected in parallel, they shall be provided with protective interlocks to ensure their correct operation.

It is recommended that the crane-supply-switch used to energize an unprotected collector wire, or collector bar, or a remote control for the crane-supply-switch be so located that as much as possible of the collector wire or collector bar is visible from that place of operation.

The above requirements should also apply in special cases, for example where:

— there are two main supply collector wires or collector bars or collector systems, either of which may be used for supplying the hoisting machine(s); or

— a main supply collector wire or collector bar is divided into isolated sections.

In cases where these requirements are not appropriate, the necessary safety shall be provided by other measures.

### 5.3.6 Crane-disconnector

**5.3.6.1 General** A hoisting machine shall be equipped with a single crane-disconnector to enable the electrical equipment to be isolated for maintenance and repair purposes, and to prevent unexpected start-up during mechanical work on the hoisting machine, except under the following circumstances:

— a crane-disconnector is not required if there are no connections and branches in the wiring system between the intended crane-disconnector position and the crane-switch specified in **5.3.7**, and the crane-switch performs the functions of the crane-disconnector and meets the requirements of **5.6**;

— a crane-disconnector is not required for a single hoisting machine which is floor controlled, and where the crane-supply-switch performs this function;

NOTE : A floor controlled hoisting machine is operated from a suspended pendant control station, a remote fixed control station, or a portable control station.

— a crane-disconnector is not necessary in cases where the voltage can be reduced to and maintained at zero by other means (e.g. locking off a diesel generator fuel supply or starter mechanism, etc.);

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— On hoisting machines with power supplied at voltages of more than 1 kV a.c., and having one or more transformers installed on the hoisting machine, supplying a low voltage system, one or more crane-disconnectors may be required on the secondary side of each transformer to isolate the low voltage sections (see also **5.5**). Circuits associated with each crane-disconnector shall be clearly identifiable, for example by:

  — separation, or

  — barriers, or

  — marking and labelling.

  NOTE : Preference should be given to the disconnection of a hoisting machine using only one crane-disconnector.

**5.3.6.2 Type** Where provisions are made against both inadvertent and unauthorized opening, the crane-disconnector shall as a minimum meet the requirements for disconnectors given in **JIS C 8201-3**. Otherwise it shall meet the requirements for switch-disconnectors given in **JIS C 8201-3**. The actuator of the crane-disconnector shall meet the requirements of **5.3.4**.

Removable collectors or plug/socket combinations may be used as crane-disconnectors when they perform the same function.

On hoisting machines with an alternative power-supply system, the changeover switch of the supplies may be used as a crane-disconnector if it has a neutral off-position and meets the requirements of **5.3.6**.

**5.3.6.3 Requirements** The requirements of **5.4**, **5.5** and **5.6** shall apply as appropriate.

### 5.3.7 Crane-switch

**5.3.7.1 General** Each hoisting machine shall have one or more crane-switches, operable from the operating control station, for emergency stop of all motion drives and, where necessary, for interrupting the electrical power supply to other equipment. Where the emergency stop function is provided by other means, a crane-switch is not required for the following:

— for hoisting machines on which only the hoisting mechanism is power-operated;

— on floor-controlled monorail hoists when the trolley travel is powered by hand or by an electric motor rated at not more than 500 W.

Load holding devices that cannot continue to hold the load when de-energized (e.g. magnets, pneumatic holding devices) shall be supplied from the supply side of the crane-switch.

**5.3.7.2 Type** The crane-switch shall as a minimum meet the requirements for switches given in **JIS C 8201-3**. This requirement can be fulfilled by one of the devices specified in **5.3.2 a**) or **c**). Contactors selected in accordance with **4.2.2** may also be used.

**5.3.7.3 Requirements** The requirements of **5.3.3** and **5.3.4** should apply as appropriate.

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### 5.3.8 Special circuits

**5.3.8.1 General** Circuits that shall not be disconnected during repair and maintenance work are regarded as special circuits and shall meet the requirements of **5.3.8.2** to **5.3.8.4**.

NOTE : Special circuits may be the following:

- circuits for socket-outlets and lighting circuits;
- circuits for lifts, repair tools and repair cranes installed in hoisting machines;
- circuits for air conditioning and ventilation;
- circuits for electrical equipment fulfilling safety measures, e.g. anti-collision device, aviation lighting;
- circuits for fire alarm systems;
- communications circuits or data links.

**5.3.8.2 Supply** Special circuits should be supplied from the supply side of the crane-disconnector specified in **5.3.6** using a dedicated disconnector (see figure 3) that shall meet the requirements of **5.6**.

**5.3.8.3 Installation** Special circuits shall be so designed and installed that their operation during repair and maintenance work on the hoisting machine does not use unprotected collector wires, collector bars or slip-ring assemblies.

**5.3.8.4 Marking and identification** Special circuits shall be identifiable by:

- permanent warning label(s) appropriately placed in proximity to the dedicated disconnector according to **5.3.8.2**; and
- a corresponding statement included in the maintenance manual; and
- a permanent warning label placed in proximity to each special circuit, or the special circuit shall be separated from other circuits; or identified by colour according to **14.2.4**.

**5.4 Devices for switching off for prevention of unexpected start-up** Devices for switching off for the prevention of unexpected start-up shall be provided. The crane-disconnector (see **5.3.6**) fulfils that function for the complete hoisting machine.

Where it is necessary to work on individual parts of a hoisting machine, additional disconnecting devices shall be provided for each part requiring separate disconnection. Disconnectors, withdrawable fuse links or withdrawable links may be used, but only when located in an enclosed electrical operating area (see **3.22**).

Such devices shall be:

- appropriate and convenient for the intended use;
- suitably located;
- readily identifiable as to which part or circuit(s) of the equipment is served (e.g. by durable marking where necessary); and

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— provided with adequate means to prevent unauthorized, inadvertent, and/or mistaken closure of the disconnecting devices (except as allowed in **5.6**).

When other means are used (e.g. a contactor switched off by a control circuit), such means for switching off are intended to be employed only for situations that include:

— no significant dismantling of machinery;

— adjustments requiring a relatively short time;

— no work carried out on the electrical equipment except when:

- there is no hazard arising from electric shock (see clause **6**) and burn;
- the switching off means cannot be negated by the work;
- the work is of a minor nature (e.g. replacement of plug-in devices without disturbing existing wiring).

NOTE : This Standard does not address provisions for switching off non-electrical power supplies, which are under consideration.

**5.5 Devices for disconnecting electrical equipment** Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out without a risk from electric shock or burn. The crane disconnector (**5.3.6**) fulfils that function for the complete hoisting machine.

Where it is necessary to work on individual parts of the electrical equipment of a hoisting machine, additional disconnecting devices shall be provided for each part requiring separate isolation. Disconnectors, withdrawable fuse links or withdrawable links may be used, but only when located in an enclosed electrical operating area.

Such devices shall be:

— appropriate and convenient for the intended use:

— suitable located;

— readily identifiable as to which part or circuit(s) of the equipment is served (e.g. by durable marking where necessary);

— provided with adequate means to prevent unauthorized, inadvertent, and/or mistaken closure of the disconnecting devices (except as allowed in **5.6**).

**5.6 Protection against unauthorized, inadvertent and/or mistaken connection** The devices described in **5.4** and **5.5** that are capable of being equipped with means to lock them in the OFF-position or disconnected state (e.g. by padlocks), in order to achieve protection against unauthorized, inadvertent, and/or mistaken connection, shall be equipped with such means. Other means of protection against connection (e.g. warning labels) may be used where a non-lockable disconnecting device (e.g. withdrawable fuse-links, withdrawable links) is located in an enclosed electrical operating area.

However, when a plug/socket combination used according to **5.3.2 d**) or **e**) is so positioned that it can be under the immediate supervision of the person carrying out the work, means for locking in the OFF-position need not be provided.

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## 6 Protection against electric shock

**6.1 General** The electrical equipment shall provide protection of persons against electric shock from:

— direct contact;

— indirect contact.

The recommended measures for this protection are given in **6.2** to **6.4**, which are derived from **JIS C 0364-4-41**. Where those recommended measures are not practicable, other measures from **JIS C 0364-4-41** may be used.

### 6.2 Protection against direct contact

**6.2.1 General** For each circuit or part of the electrical equipment, the measures of either **6.2.2** or **6.2.3** and, where applicable, **6.2.4** shall be applied. Where those measures are not practicable, other measures for protection against direct contact (e.g. by using barriers, by placing out of reach, using obstacles, using construction or installation techniques that prevent access) as defined in **JIS C 0364-4-41** (**412.2**, **412.3** and **412.4**) may be applied (see **6.2.5** and **6.2.6**).

When the equipment is located in places open to all persons, which can include handicapped persons and children, measures of either **6.2.3**, or **6.2.2** with a minimum degree of protection against direct contact corresponding to IP4X or IPXXD (see **JIS C 0920**), shall be applied.

**6.2.2 Protection by enclosures** Live parts shall be located inside enclosures that conform to the relevant requirements of clauses **4**, **12**, and **15** (see also **IEC 60536**), and that provide protection against direct contact of at least IP2X or IPXXB (see **JIS C 0920**).

Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD. Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only under one of the following conditions:

a) the use of a key or tool is necessary for access by skilled or instructed persons. For enclosed electrical operating areas, special requirements may apply (see **JIS C 0364-4-41**, **JIS C 0364-4-47** or **JIS C 8480** annex 2).

   Live parts on the inside of doors shall be protected against direct contact to at least IP1X or IPXXA. Live parts, that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected, shall be protected against direct contact to at least IP2X or IPXXB;

b) the disconnection of live parts inside the enclosure before the enclosure may be opened. This may be accomplished by interlocking the door with a disconnector so that the door can only be opened when the disconnector is open, and so that the disconnector can only be closed when the door is closed. However, a special device or tool as prescribed by the supplier may permit skilled persons to defeat the interlock provided that:

   — it is possible at all times while the interlock is defeated to open the disconnector;

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— upon closing the door, the interlock is automatically restored.

Where more than one door can provide access to live parts, care should be taken to implement the intent of this subclause. All parts that are still live after switching off the disconnecting device(s) shall be protected against direct contact to at least IP2X or IPXXB (see **JIS C 0920**). Such parts shall be marked with a warning sign in accordance with **17.2** (see also **14.2.4** for identification of conductors by colour).

Excepted from this requirement for marking are:

— parts that can be live only because of connection to interlocking circuits and that are distinguished by colour as potentially live in accordance with **14.2.4**;

— the supply terminals of the disconnector when it is mounted alone in a separate enclosure.

c) Opening without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (see **JIS C 0920**). Where barriers provide this protection, either they shall require a tool for their removal, or all live parts protected by them shall be automatically disconnected when the barrier is removed.

**6.2.3 Protection by insulation of live parts** Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction.

Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal service conditions.

Paints, varnishes, lacquers, and similar products alone are generally considered to be inadequate for protection against electric shock under normal service conditions.

**6.2.4 Protection against residual voltages** Live parts having a residual voltage greater than 60 V after the supply has been disconnected shall be discharged to 60 V or less within a time period of 5 s after disconnection of the supply voltage, provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard, and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitances.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (e.g. pins), the discharge time shall not exceed 1 s, otherwise such conductors shall be protected against direct contact to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved [e.g. in the case of removable collectors on collector wires, collector bars, or slip-ring assemblies (see **13.8.4**)], additional disconnecting devices or an appropriate warning device shall be applied.

**6.2.5 Protection by barriers** For protection by barriers, see **JIS C 0364-4-41**, **412.2**.

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**6.2.6 Protection by placing out of reach or protection by obstacles** For protection by placing out of reach, see **JIS C 0364-4-41, 412.4**. For protection by obstacles, see **JIS C 0364-4-41, 412.3**.

NOTE : A handrail is considered to be an obstacle.

For collector wire systems or collector bar systems with a degree of protection less than IP2X, see **13.8.1**.

### 6.3 Protection against indirect contact

**6.3.1 General** Protection against indirect contact (**3.33**) is intended to prevent hazardous conditions in the event of an insulation failure between live parts and exposed conductive parts.

For each circuit or part of the electrical equipment, at least one of the measures in accordance with **6.3.2** to **6.3.3** shall be applied. Collector wires, collector bars and slip-ring assemblies shall meet the requirements of **13.8.1**.

Protection against indirect contact can be achieved by:

— measures to prevent the occurrence of a hazardous touch voltage; or

— automatic disconnection of the supply before the time of contact that a touch voltage can become hazardous.

These measures necessitate the following co-ordination between:

— the type of supply and earthing system;

— the impedance values of the different elements of the protective bonding system;

— the characteristics of the protective devices used to detect insulation failure.

NOTE : For classes of equipment and protective provisions, see **IEC 61140**.

#### 6.3.2 Measures to prevent the occurrence of a hazardous touch voltage

**6.3.2.1 General** Measures to prevent the occurrence of a hazardous touch voltage include the following:

— use of class II equipment or by equivalent insulator;

— electrical separation;

— selection or design of the supply system.

**6.3.2.2 Protection by use of class II equipment or by equivalent insulation** This measure is intended to prevent the occurrence of hazardous touch voltages on the accessible parts through a failure in the basic insulation.

This protection is provided by one or more of the following means:

— use of class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation in accordance with **IEC 61140**);

— use of switchgear and controlgear assemblies having total insulation in accordance with **JIS C 8480** annex 2;

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— application of supplementary or reinforced insulation in accordance with **JIS C 0364-4-41, 413.2.**

**6.3.2.3 Protection by electrical separation** Electrical separation of an individual circuit is intended to prevent a hazardous touch voltage through contact with exposed conductive parts that can be energized by a failure in the basic insulation of the live parts of that circuit.

For this type of protection, the requirements of **JIS C 0364-4-41, 413.5** apply.

**6.3.2.4 Supply system design** This protection is provided by the use of a supply system designed with its neutral point either insulated or having a high impedance to earth so that an earth fault will not result in a hazardous touch voltage.

**6.3.3 Protection by automatic disconnection of supply** Automatic disconnection of the supply of any circuit affected by the occurrence of an insulation failure is intended to prevent a hazardous condition resulting from a touch voltage.

This protective measure comprises both:

— the connection of exposed conductive parts to the protective bonding circuit (see clause 8);

— either:

a) the use of protective devices for the automatic disconnection of the supply in the event of an insulation failure in TN or TT systems, or

b) the use of earth fault detection or residual current detection to initiate automatic disconnection of IT systems. If earth fault detection is used, it is permissible for the first fault to initiate only an alarm signal instead of automatic disconnection.

For this type of protection, the requirements of **JIS C 0364-4-41, 413.1** shall apply.

## 6.4 Protection by the use of PELV

**6.4.1 General requirements** The use of PELV (protective extra-low voltage) is to protect persons against electric shock from indirect contact and limited area direct contact.

PELV circuits shall satisfy all of the following conditions:

a) the nominal voltage shall not exceed:

— 25 V a.c. (r.m.s.) or 60 V (ripple-free) d.c. when the equipment is normally used in dry locations and when large area contact of live parts with the human body is not expected;

— 6 V a.c. (r.m.s.) or 15 V (ripple-free) d.c. in all other cases;

NOTE : "Ripple-free" is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10 % r.m.s.

b) one side of the circuit or one point of the source of the supply of that circuit shall be connected to the protective bonding circuit;

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c) live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer (see **JIS C 9742**);

d) conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of **14.1.3** shall apply;

e) plugs and socket-outlets for a PELV circuit shall conform to the following:

1) plugs shall not be able to enter socket-outlets of other voltage systems;

2) socket-outlets shall not admit plugs of other voltage systems.

**6.4.2 Sources for PELV** The source for PELV shall be one of the following:

— a safety isolating transformer;

— a source of current providing a degree of safety equivalent to that of the safety isolating transformer (e.g. a motor generator with winding providing equivalent isolation);

— an electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel driven generator);

— an electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in **6.4.1**.

## 7 Protection of equipment

**7.1 General** This clause **7** details the measures to be taken to protect equipment against the effects of:

— overcurrent arising from a short circuit;

— overload current;

— abnormal temperature;

— loss of or reduction in the supply voltage;

— overspeed of motors;

— earth fault;

— incorrect phase sequence;

— overvoltage due to lightning and switching surges.

If one of these malfunctions causes the operation of a protective device resulting in the stopping of a motion drive motor, an automatic restart shall be prevented.

NOTE : This requirement can be met for example by the means of:

— a crane-switch which can only be switched on if all operator control devices are in the off position;

— operator control devices which automatically return to the off position.

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Where only a part of a hoisting machine or a group of hoisting machines working together in a co-ordinated manner is affected by the operation of a protective device, such operation shall initiate appropriate control responses to ensure co-ordination (see also **9.3.4**).

## 7.2 Overcurrent protection

**7.2.1 General** Overcurrent protection shall be provided where the current in a hoisting machine circuit can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be used are detailed in **7.2.10**.

**7.2.2 Supply conductors** Unless otherwise specified by the user, the supplier of the electrical equipment shall not be responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device (see **7.2.10** and **18.5**) (see annex A).

**7.2.3 Power circuits** Devices for detection and interruption of overcurrent, selected in accordance with **7.2.10**, shall be applied to each live conductor.

Where the cross-sectional area of the neutral conductor is at least equal to or equivalent to that of the phase conductors, it is not necessary to provide overcurrent detection for the neutral conductor nor a disconnecting device for that conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated phase conductors, the measures detailed in **473.3.2.1**, item **b**) of **JIS C 0364-4-473** shall apply.

In IT-systems, it is recommended that the neutral conductor is not used. However, where a neutral conductor is used, the measures detailed in **JIS C 0364-4-473**, **473.3.2.2** shall apply.

**7.2.4 Control circuits** Conductors of control circuits directly connected to the supply voltage and of circuits feeding control circuit transformers shall be protected against overcurrent in accordance with **7.2.3**.

In control circuits fed through a transformer, of which one end of the secondary winding is connected to the protective bonding circuit, an overcurrent protective device is required only in the other secondary circuit conductor.

**7.2.5 Socket outlets and their associated conductors** Overcurrent protection shall be provided for the circuits feeding the general purpose socket outlets intended primarily for supplying power to maintenance equipment.

Overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket outlets.

**7.2.6 Lighting circuits** All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of overcurrent devices separate from those protecting other circuits.

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**7.2.7 Transformers** Transformers shall be protected against overcurrent in accordance with **IEC 60076-5** and **JIS C 9742** as appropriate. Such protection shall (see also **7.2.10**):

— avoid nuisance tripping due to transformer magnetizing inrush currents;

— avoid a winding temperature rise in excess of the permitted value for the insulation class of transformer when it is subjected to the effects of a short circuit at its secondary terminals.

The type and setting of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier.

**7.2.8 Location of overcurrent protective devices** An overcurrent protective device shall be located at the point where the conductor to be protected is connected to its supply. Where that is not possible, no overcurrent protection is required for those conductors with current carrying capacity less than that of the supply conductors, provided that the possibility of a short circuit is reduced by all of the following measures:

— the current carrying capacity of the conductor is at least equal to that required for the load;

— each connecting conductor to the overcurrent protective devices is no longer than 3 m;

— the conductor is protected by an enclosure or duct.

If the above three measures are not practicable, measures according **JIS C 8480** annex 2 shall be taken.

**7.2.9 Overcurrent protective devices** The rated short circuit breaking capacity shall be at least equal to the prospective fault current at the point of installation. Where the short circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g. from motors, from power factor correction capacitors), those currents shall be taken into considerations.

A lower breaking capacity is permitted where another protective device (e.g. the overcurrent protective device for the supply conductors – see **7.2.2**) having the necessary breaking capacity is installed on the supply side. In that case, the characteristics of the two devices shall be co-ordinated so that the let-through energy ($I^2 t$) of the two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected by that device (see **JIS C 8201-2**, annex A).

NOTE : The use of such a co-ordinated arrangement of overcurrent protective devices can result in the operation of both overcurrent protective devices.

Overcurrent protective devices for power circuits include fuses and circuit-breakers. Electronic devices designed to reduce or to limit the current in protected circuits may also be used. Where fuses are used, a type readily available in the country of use shall be selected, or arrangements shall be made with the user for the supply of spare parts.

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**7.2.10 Rating and setting of overcurrent protective devices** The rated current of fuses or the setting current of other overcurrent protective devices shall be selected as low as possible but shall be adequate for the anticipated overcurrents (e.g. during starting of motors or energizing of transformers). When selecting those protective devices, considerations should be given to the protection of control switching devices against damage due to overcurrents (e.g. welding of the control switching device contacts).

The rated current or setting of an overcurrent protective device is determined by the current carrying capacity of the conductors to be protected by that device in accordance with **13.4**. This should take into account the needs of co-ordination with other electrical devices in the protected circuit. The recommendations of the supplier of these devices should be followed.

**7.3 Overload protection of motors** Overload protection of motors shall be provided for each motor rated at more than 2 kW, and is recommended for each motor rated at less than 2 kW. In applications where an automatic interruption of the motor operation is unacceptable (e.g. fire pumps), the overload detection shall give a warning signal to which the operator can respond. For motors that cannot be overloaded (e.g. torque motors, motion drives that either are protected by mechanical overload protection devices or are adequately dimensioned), the overload protective devices may be omitted. Overload protection of motors can be achieved by the use of devices such as overload protected devices, temperature sensing devices, or current limiting devices.

NOTE : Overload protective devices detect the time and current relationship ($I^2 t$) in a circuit that are in excess of the rated full load of the circuit and initiate appropriate control responses.

Detection of overload(s) (except in the case of current limitation or built-in thermal protection in accordance with **IEC 60034-11**) shall be provided in each live conductor except for the neutral conductor. However, the number of overload detection devices may be reduced at the request of the user (see annex A). For motors having single phase or d.c. power supplies, detection on only one unearthed live conductor is permitted.

Where overload protection is achieved by switching off, the switching device shall switch off all live conductors. The switching of the neutral conductor may not be necessary (see **7.2.3**).

Where motors with special duty ratings are called upon to start or to brake frequently (e.g. motors used for rapid traverse, locking, plugging, high frequency inching), it can be difficult to provide overload protection with a time constant comparable with that of the winding to be protected. The use of appropriate protective devices designed to accommodate special duty motors is recommended.

The use of motors with built-in thermal protection (see **IEC 60034-11**) is recommended in situations where the cooling can be impaired (e.g. duty environments).

Depending upon the kind of motor, protection under stalled rotor or loss of phase conditions is not always ensured by built-in thermal protection, and additional protection should then be provided.

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**7.4 Abnormal temperature protection** Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures, and therefore, can cause a hazardous condition, shall be provided with suitable detection to initiate an appropriate control response. An example is a resistance heating circuit that is short-time rated or which loses its cooling medium.

**7.5 Protection against supply interruption or voltage reduction and subsequent restoration** Where a supply interruption or a voltage reduction can cause a hazardous condition, such as damage to the hoisting machine, or to the load, undervoltage protection shall be provided (e.g. to switch off the hoisting machine) at a predetermined voltage level. Undervoltage protection may be omitted on a manually controlled hoisting machine.

Where the operation of the hoisting machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection may be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the hoisting machine.

**7.6 Motor overspeed protection** Overspeed protection shall be provided where overspeeding can occur and could possibly cause a hazardous condition, taking into account measures in accordance with **9.5**. Overspeed protection shall initiate appropriate control responses.

NOTES 1 This protection can consist, for example, of a centrifugal switch or speed limit monitor. The overspeed protection should operate in such a manner that the mechanical speed limit of the motor or its load is not exceeded.

2 Inadmissible high speeds could occur, for example, in hoisting drives equipped with d.c. motors.

**7.7 Earth fault/residual current protection** In addition to providing earth fault/residual current protection for automatic disconnection as described in **6.3**, this protection can be used to reduce damage to equipment due to earth fault currents less than the detection level of the overcurrent protection.

The setting of the devices shall be as low as possible consistent with correct operation of the equipment.

**7.8 Phase sequence protection** Where an incorrect phase sequence of the supply voltage can cause a hazardous condition or damage to the hoisting machine, protection shall be provided.

NOTE : Conditions of use that may lead to an incorrect phase sequence include:

— a hoisting machine transferred from one supply to another;

— a mobile crane with a facility for connection to an external power supply.

A hoisting machine with provision for connection of an auxiliary electric power supply (e.g. for repairs) or an alternative power supply (e.g. in case of emergency) shall have a phase sequence protection device to ensure the correct motor rotation.

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**7.9 Protection against overvoltages due to lightning and to switching surges** Protective devices can be provided to protect against the effects of overvoltages due to lightning or to switching surges.

Devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting and switching device.

Devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

## 8 Equipotential bonding

**8.1 General** This clause provides requirements for both protective bonding and operational bonding. Figure 4 illustrates these concepts.

### 8.2 Protective bonding circuit

**8.2.1 General** The protective bonding circuit consists of:

— PE terminal(s) (see **5.2**);

— the conductive structural parts of the electrical equipment and the hoisting machine;

— the protective conductors in the equipment of the hoisting machine, including sliding contacts where they are part of the circuit.

On mobile cranes with on-board power supplies, the protective circuits, the exposed conductive parts, and the extraneous conductive parts shall all be connected to a protective bonding terminal to provide protection against electric shock. When a mobile crane is also capable of being connected to an external incoming supply, the protective bonding terminal shall be the connection point for the external protective conductor.

NOTE : When the supply of electrical energy is self-contained within stationary, mobile, or movable items of equipment, and when there is no external supply connected (e.g. when an on-board battery charger is not connected), there is no need to connect such equipment to an external protective conductor.

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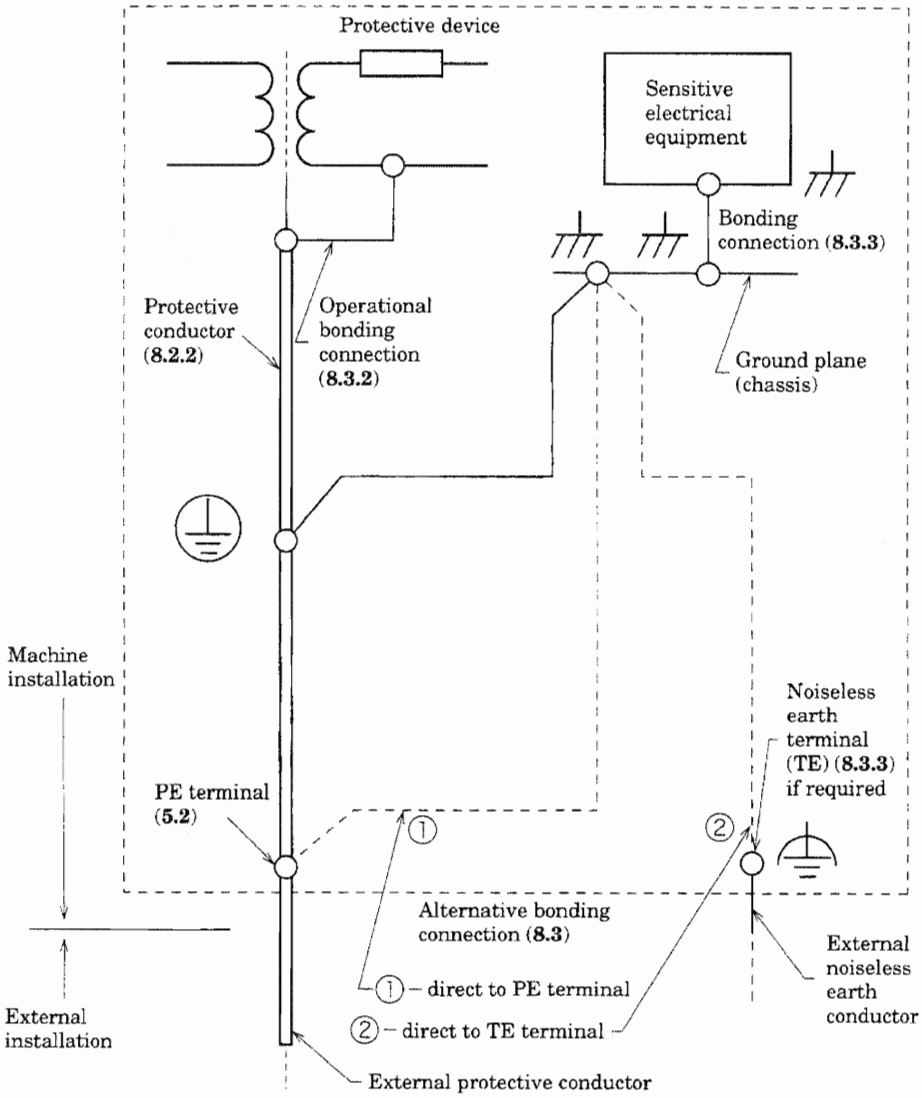


**Figure 4 Example of equipotential bonding for electrical equipment of a hoisting machine**

All part of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit.

Any structural part of the electrical equipment or of the hoisting machine may be used as part of the protective bonding circuit provided that it satisfies the requirements of **JIS C 0364-5-54**.

If an IT distribution system is used, the hoisting machine structure shall be used as part of the protective bonding circuit in conjunction with an earth fault supervision system. The structural bonding is not required where all the equipment provided is in accordance with **6.3.2.2**.

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**8.2.2 Protective conductors** Protective conductors shall be identified in accordance with **14.2.2**.

Copper conductors should be used. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of the allowable copper conductor, and such conductors shall be not less than 16 $mm^2$ in cross-sectional area.

The cross-sectional area of protective conductors shall be determined in accordance with the following requirements:

— **JIS C 0364-5-54, 543**, or

— **JIS C 8480** annex 2, **7.4.3.1.7**.

This requirement is met in most cases where the relationship between the cross-sectional area of the phase conductors associated with that part of the equipment and the cross-sectional area of the associated protective conductor is in accordance with table 1.

**8.2.3 Continuity of the protective bonding circuit** All exposed conductive parts of the electrical equipment and the hoisting machine shall be connected to the protective bonding circuit. Where a part is removed for any reason (e.g. routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted.

The resistance of any part of the protective bonding circuit shall be such that a hazardous touch voltage will not be present on exposed conductive parts in the event of an insulation failure (see **JIS C 0364-5-54, 543.2**, and **543.3**).

Connection and bonding points shall be so designed that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and conductors of aluminium or aluminium alloys are used, particular consideration should be given to the problems of electrolytic corrosion.

Metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as protective conductors. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (e.g. cable armouring, lead sheath) shall be connected to the protective bonding circuit.

Where the electrical equipment is mounted on lids, doors, or cover plates, continuity of the protective bonding circuit shall be ensured, and it is recommended that a protective conductor (see **8.2.2**) is used. Otherwise fastenings, hinges or sliding contacts designed to have a low resistance shall be used.

The continuity of the protective conductor in cables that are exposed to damage (e.g. flexible trailing cables) shall be ensured by appropriate measures (e.g. monitoring).

For requirements for the continuity of the protective conductor using collector wires, collector bars and slip-ring assemblies, see **13.8.2**.

Rails of hoisting machines may be connected to the protective bonding circuit. However, they shall not replace the protective conductor (e.g. cable, collector wire or collector bar) from the supply source to the hoisting machine.

The electrical equipment of hoisting machines intended to be used at different sites (transportable hoisting machines) shall be designed to accept different power supply conditions. When used with IT or TT systems, the protective bonding circuit of the hoisting machine shall be connected to the earthing system of the site.

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**8.2.4 Exclusion of switching devices from the protective bonding circuit** The protective bonding circuit shall not incorporate a switching device, an overcurrent protective device (e.g. switch, fuse) nor a means for current detection for such devices. The only means permitted for interruption of the protective conductors shall be links intended to be opened only by instructed or skilled persons for certain test or measurement purposes, preferably by using a tool (see also **JIS C 0364-5-54**, **543.3**). Exception: it is permissible to include such devices that do not interrupt the protective bonding circuit, that have electrical characteristics that under all circumstances ensure prevention of a hazardous voltage rise in any part of the circuit, and that do not impair the performance of the circuit.

**8.2.5 Parts that need not be connected to the protective bonding circuit** It is not necessary to connect exposed conductive parts to the protective bonding circuit where those parts are mounted so that they do not constitute a hazard because:

— they cannot be touched on large surfaces or grasped with the hand and they are small in size (less than approximately 50 mm × 50 mm);

— they are located so that either contact with live parts, or an insulation failure, is unlikely.

This applies to small parts such as screws, rivets, and nameplates, and to parts inside an enclosure, irrespective of their size (e.g. electromagnets of contactors or relays and mechanical parts of devices) (see also **JIS C 0364-4-47**, **471.2.2**).

**8.2.6 Interruption of the protective bonding circuit** Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall not be interrupted before the live conductors have been disconnected, and shall be reestablished before any live conductor is reconnected. This also applies to removable or withdrawable plug-in units (see also **14.4.5**).

Metallic housings of plug/socket combinations shall be connected to the protective bonding circuit, except where used for PELV.

**8.2.7 Protective conductor connecting points** All protective conductors shall be terminated in accordance with **14.1.1**. The protective conductor connecting points shall have no other function and shall not be used, for example, to attach or connect appliances or parts.

Each protective conductor connecting point shall be identified as such using the symbol **IEC 60417-2-5019**.

Graphical symbol by **IEC 60417-2-5019**

Alternatively, terminals for the connection of the protective conductor may be identified by the bicolour combination GREEN-AND-YELLOW. For the use of the letters PE, see **5.2**.

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## 8.3 Bonding for operational purposes

**8.3.1 General** The objective of operational bonding is to minimize:

— the consequence of an insulation failure on the operation of the machine (see **8.3.2**);

— the consequences of electrical disturbances on the operation of sensitive electrical equipment (see **8.3.3**).

**8.3.2 Bonding to the protective circuit** One method for protection against unintended operation as a result of insulation failures is achieved by connecting one side of the control circuit fed by a transformer to the protective bonding circuit, with the control devices connected in accordance with **9.1.4**. This connection shall be made at the source of the control circuit supply.

Attention is drawn to the fact that by omitting the connection of the exposed conductive parts of the devices to the protective bonding circuit as permitted by **6.3.2.2** and **6.3.2.3**, the safety measures of this subclause may not be effective.

**8.3.3 Bonding to a common reference potential** The effects of disturbances can be reduced by employing a low resistance conductor in a low impedance network that is used as a reference level for high frequency signals within the electrical equipment (e.g. the chassis or ground plane). The design of the bonding connections shall be such as to reduce the impedance to the ground plane as much as possible.

Such termination points shall be identified by the symbol **IEC 60417-2-5020** (see figure 4):

Graphic symbol by **IEC 60417-2-5020**

Bonding to a common reference potential other than that provided by the protective bonding circuit or to the terminal for connection to an external (noiseless earth) earth conductor shall be permitted, providing the requirements of clauses **6** and **7** are met.

Single point bonding connected directly to a point as close as possible to the PE terminal (see figure 4 ①) or to its own terminal for connection to an external (noiseless) earth conductor shall be used, where appropriate, to minimize common mode interferences (see figure 4 ②). This latter terminal shall be identified by the symbol **IEC 60417-2-5018**:

Graphical symbol by **IEC 60417-2-5018**

## 9 Control circuits and control functions

**9.1 Control circuits** Not applicable for hand-held direct-control devices (see **3.31**).

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**9.1.1 Control circuit supply** Transformers shall be used for supplying the control circuits. Such transformers shall have separate windings. Where several transformers are used, it is recommended that the windings of those transformers be connected in such a manner that the secondary voltages are in phase.

Where d.c. control circuits are connected to the protective bonding circuit (see **8.2.1**), they shall be supplied from a separate winding of the a.c. control circuit transformer, or by another control circuit transformer.

Transformers are not mandatory for machines with a single motor starter and a maximum of two control devices (e.g. interlock device, start/stop control station).

For testing and/or maintenance purposes, hoisting machines with more than one electrical motion drive should incorporate means to energize a drive control circuit without energizing its power circuit.

**9.1.2 Control circuit voltages** The value of the control voltage should be consistent with the correct operation of the control circuit. The nominal voltage shall not exceed 277 V when supplied from a transformer.

**9.1.3 Protection** Control circuits shall be provided with overcurrent protection in accordance with **7.2.4** and **7.2.10**.

**9.1.4 Connection of control devices** In control circuits with one side connected (or intended to be connected) to the protective bonding circuit (see **7.2.4**), one terminal (preferably always having the same marking) of the operating coil of each electromagnetically operated device or one terminal of any other electrical device shall be connected directly to that side of the control circuit. All switching elements (e.g. contacts) of control devices that operate the coil or the device shall be inserted between the no bonding side of the coil or device and no bonding side of the control circuit.

The following exceptions are permitted:

— contacts of protective devices (e.g. overload relays) may be connected between that side connected to the protective bonding circuit and the coils, provided that the conductors between such contacts and the coils of the control devices on which the relay contacts operate are in the same control enclosure, and that the connection is so short and of a type that an earth fault is unlikely;

— where the requirements of **9.4.3.1** are met.

## 9.2 Control functions

**9.2.1 Start functions** Start functions shall operate by energizing the relevant circuit (see **9.2.5.2**).

**9.2.2 Stop functions** There are three categories of stops as follows:

— category 0: stopping by immediate removal of power to the hoisting machine actuators (i.e. an uncontrolled stop – see **3.63**);

— category 1: a controlled stop (see **3.12**) with power available to the hoisting machine actuators to achieve the stop and then removal of power when the stop is achieved;

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— category 2: a controlled stop with power left available to the hoisting machine actuators.

NOTE : With the exception of emergency stop and/or emergency switching off (see **9.2.5.4**), and depending upon the risk assessment, removal of power may be accomplished by the use of either electromechanical or solid-state components.

**9.2.3 Operating modes** Each hoisting machine can have one or more operating modes determined by the type of hoisting machine and its application.

When a hazardous condition can result from a mode selection, such selection shall be prevented by suitable means (e.g. key operated switch, access code). Mode selection by itself shall not initiate hoisting machine operation. A separate action by the operator shall be required.

Safeguarding shall remain effective for all operating modes. (See **9.2.4** for suspension of safeguarding under special conditions.)

Indication of the selected operating mode shall be provided (e.g. the position of a mode selector, the provision of an indicating light, a visual display indication).

**9.2.4 Suspension of safeguarding** Where it is necessary to suspend safeguarding, (e.g. for setting or maintenance purposes), a mode selection device or means capable of being secured (e.g. locked) in the desired mode shall be provided so as to prevent automatic operation. In addition, one or more of the following means should be provided:

— initiation of motion by a hold-to-run device or by a similar control device;

— a portable control station (not cable-less) with an emergency stop device and, where appropriate, an enabling device. Where a portable station is in use, motion may be initiated only from that station;

— limitation of the speed or the power of motion;

— limitation of the range of motion.

**9.2.5 Operation**

**9.2.5.1 General** The necessary interlocks (see **9.3**) shall be provided for safe operation.

Measures shall be taken to prevent movement of the hoisting machine in an unintended manner after any stopping of the hoisting machine (e.g. due to locked-off condition, power supply fault, battery replacement, lost signal condition with cableless control).

A restart of the hoisting machine shall be possible only by an intended restart command.

**9.2.5.2 Start** The start of an operation shall be possible only when all of the safeguards are in place and are functional except for conditions as described in **9.2.4**.

Suitable interlocks shall be provided to secure correct sequential starting.

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On hoisting machines requiring the use of more than one control station to initiate a start:

— each control station shall have a separate manually actuated start control device;

— all required conditions for hoisting machine operation shall be met;

— all start control devices shall be in the released (off) position before a start may be permitted;

— all start control devices shall be actuated concurrently (see **3.7**).

**9.2.5.3 Stop** Category 0, category 1 and/or category 2 stops shall be provided where indicated by the risk assessment and the functional requirements of the hoisting machine (see **4.1**). Category 0 and category 1 stops shall be operational regardless of operating modes (see **9.2.3**) and category 0 shall take priority. Stop functions shall override related start functions (see **9.2.5.2**).

Where required, facilities to connect protective devices and interlocks shall be provided. If such a protective device or interlock causes a stop of the hoisting machine, it may be necessary for that condition to be signalled to the logic of the control system. The reset of the stop function shall not initiate any hazardous condition.

**9.2.5.4 Emergency operations (emergency stop, emergency switching off)**

**9.2.5.4.1 General** This Standard specifies the requirements for the emergency stop and the emergency switching off functions of the emergency operations listed in annex C, both of which, in this Standard, are initiated by a single human action. The emergency stop function is restricted to the movement of motion drives. For other safety-related functions, see **11.3.4**.

An emergency operation function shall have only hardwired electromechanical components. In addition, its operation shall not depend on electronic logic (hardware or software), or on the transmission of commands over a communications network or link.

**9.2.5.4.2 Emergency stop** Hoisting machines shall have an emergency stop function, which shall at least stop the motion drives. This emergency stop shall function as a category 0 stop.

In addition to the requirements for stop (see **9.2.5.3**), the emergency stop function has the following requirements:

— it shall override all other functions and operations in all modes;

— power to the hoisting machine actuators of motion drives that can cause a hazardous condition(s) shall be removed as quickly as possible without creating other hazards (e.g. by the provision of mechanical brakes requiring no external power for stopping);

— reset shall not initiate a restart.

**9.2.5.4.3 Emergency switching off** The functional aspects of emergency switching off are given in **JIS C 0364-4-46**.

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Emergency switching off should be provided where:

— protection against direct contact (e.g. with collector wires, collector bars, slip-ring assemblies and controlgear in electrical operating areas) is achieved only by placing them out of reach or by obstacles (see **6.2.6**); or

— there is the possibility of other hazards or damage caused by electricity.

Emergency switching off is accomplished by disconnecting the incoming supply of the hoisting machine (crane-supply-switch) or parts of it, effecting an emergency stop of the hoisting machine or the drives connected to those parts.

**9.2.5.5 Monitoring of command actions** Movement or action of a hoisting machine or part of a hoisting machine that can result in a hazardous condition shall be monitored. On manually controlled hoisting machines, operators can provide some of this monitoring. Conditions that cannot reasonably be expected to be monitored by the operator will require means which may include overtravel limiters, motor overspeed detection, mechanical overload detection or anti-collision devices.

**9.2.5.6 Hold-to-run controls** Hold-to-run controls shall require continuous actuation of the control device(s) to achieve operation.

**9.2.5.7 Two-hand control** Three types of two-hand control are available, the selection of which is determined by the risk assessment. These shall have the following features:

— Type I: This type requires the following:

  • the provision of two control devices and their concurrent (see **3.7**) actuation by both hands;

  • continuous concurrent actuation during the hazardous condition:

  • hoisting machine operation shall cease upon the release of either one or both of the control devices when hazardous conditions are still present.

— Type II: A type I control requiring the release of both control devices before hoisting machine operation may be reinitiated.

— Type III: A type II control requiring concurrent actuation of the control devices as follows:

  • it shall be necessary to actuate the control devices within a certain time limit of each other, not exceeding 0.5 s (see annex A);

  • where this time limit is exceeded, both control devices shall be released before operation may be reinitiated.

**9.2.5.8 Enabling device** An enabling device is an additional manually operated control device used in conjunction with a start control and which, when continuously actuated, allows a hoisting machine to function.

When an enabling device is provided as a part of a system, it shall be designed to allow motion when actuated in one position only. In any other position motion shall be stopped.

It shall have the following features:

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— be connected to a category 0 stop or to a category 1 stop (see **9.2.2**);

— be designed in consideration of ergonomic principles;

— for a two-position type:

  • position 1: off-function of the switch (actuator is not operated);

  • position 2: enabling function (actuator is operated);

— for a three-position type:

  • position 1: off-function of the switch (actuator is not operated);

  • position 2: enabling function (actuator is operated in its mid position);

  • position 3: off-function (actuator is operated past its mid position).

When returning from position 3 to position 2, the function shall not be enabled.

**9.2.5.9 Operator controlled hoisting machines** Operator controlled hoisting machines shall use either hold-to-run controls or two-position enabling devices. This requirement does not apply to cabin controlled hoisting machines with overtravel limiting devices where no hazardous condition can occur.

**9.2.5.10 Handheld direct-control devices** Handheld direct-control devices are permitted for hoisting machines operating at rated values not exceeding 500 V a.c. and 7.5 kW. They shall be protected against indirect contact in accordance with **6.3.2.2**.

**9.2.5.11 Enabling of an operator control station** On a hoisting machine with more than one operator control station for the same motion drive, (e.g. cabin control and floor control), only one operator control station shall be enabled at any given time. For emergency stop, see **9.2.5.4.2** and **10.7.1**.

Means shall be provided to indicate the operational status of the operator control station.

**9.2.6 Combined start and stop controls** Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be used for functions which cannot result in a hazardous condition.

**9.2.7 Cable-less controls**

**9.2.7.1 General** This subclause **9.2.7** deals with the functional requirements of control systems employing cable-less (e.g. radio, infra-red) techniques for transmitting commands and signals between a hoisting machine control system and operator control station(s).

NOTE : Some of these application and system integrity considerations may also be applicable to control functions employing serial data communication techniques where the communications link uses a cable (e.g. coaxial, twisted-pair, optical).

Means shall be provided to readily remove or disconnect the power supply of the operator control station.

Means (e.g. key operated switch, access code) shall be provided, as necessary, to prevent unauthorized use of the operator control station.

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Each operator control station shall carry an unambiguous indication of which hoisting machine(s) is intended to be controlled by that operator control station.

The operator control station shall be so designed that a mechanical shock (e.g. caused by falling to the floor) is unlikely to cause an unintended signal command.

Where the operator control station could be dropped and not be immediately retrievable, other means to stop the hoisting machine [e.g. emergency stop or emergency switching off device(s)], shall be provided within the working area of the operator.

**9.2.7.2 Control limitation** Measures shall be taken to ensure that control commands:

— affect only the intended hoisting machine:

— affect only the intended functions.

Measures shall be taken to prevent the hoisting machine from responding to signals other than those from the intended operator control station(s).

Where necessary, means shall be provided so that the hoisting machine can only be controlled from operator control stations in one or more predetermined zones or locations.

**9.2.7.3 Stop** Operator control stations shall include a separate and clearly identifiable means to initiate the emergency stop function on the hoisting machine (see **9.2.5.4.2** and **10.7.1**). This actuating means to initiate the emergency stop function shall not be marked or labelled as an emergency stop device.

The response time of a cable-less control system shall not exceed 550 ms for a stop command.

A hoisting machine which is equipped with cable-less control shall have a means of automatically initiating the stopping of the hoisting machine and of preventing a potentially hazardous operation in the following situations:

— when a stop signal is received;

— when a fault is detected in the system;

— when a valid signal has not been detected within a specified period of time (see annex A), except when a hoisting machine is executing a pre-programmed task taking it outside the range of the cable-less control where no hazardous condition can occur.

NOTE : A valid signal includes the signal that confirms that communication is established and maintained. Practical values of time are typically between 0.5 s and 2 s according to foreseen use and characteristics of hoisting machines.

**9.2.7.4 Serial data communication** In a hoisting machine where the control of safety-related functions relies on serial data transfer, correct communications shall be ensured by using an error detection method that is able to cope with up to three error bits in any command sequence.

NOTE : Error detection methods in accordance with **IEC 60870-5-1** are recommended.

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**9.2.7.5 Use of more than one operator control station** Where a hoisting machine has more than one operator control station, measures shall be taken to ensure that only one control station can be enabled at a given time. An indication of which operator control station is in control of the hoisting machine shall be provided at suitable locations as determined by the risk assessment of the hoisting machine.

**9.2.7.6 Battery-powered operator control stations** A variation in the battery voltage shall not cause a hazardous condition. If one or more potentially hazardous motions are controlled using a battery-powered operator control station, a clear warning shall be given to the operator when a variation in battery voltage exceeds specified limits. Under those circumstances the operator control station shall remain functional long enough to put the hoisting machine into a non-hazardous condition.

NOTE : A time period of 10 min is normally acceptable.

**9.3 Protective interlocks**

**9.3.1 Reclosing or resetting of an interlocking safeguard** The reclosing or resetting of an interlocking safeguard shall not initiate hoisting machine motion or operation where that can result in a hazardous condition.

**9.3.2 Overtravel limits** Where an overtravel can cause a hazardous condition, a position sensor or limit switch shall be provided to initiate appropriate control action, [(e.g. the switching off of the relevant motion drives or of the hoisting machine) (see also **9.5**)].

When a limiting device has initiated the stopping of the motion of a manually operated hoisting machine, a restart shall be possible, but only in the opposite direction.

**9.3.3 Operation of auxiliary functions** The correct operation of auxiliary functions shall be checked by appropriate devices (e.g. temperature sensors).

Where the non-operation of a motor or device for an auxiliary function (e.g. lubrication, supply of coolant, cooling fan) can cause a hazardous condition, appropriate interlocking shall be provided.

**9.3.4 Interlocks between different operations and for contrary motions** All contactors, relays, and other control devices that control elements of the hoisting machine and that can cause a hazardous condition when actuated at the same time (e.g. those which initiate contrary motion), shall be interlocked against incorrect operation.

Reversing contactors (e.g. those controlling the direction of rotation of a motor) shall be interlocked in such a way that in normal service no short circuit can occur when switching.

Where, for safety or for continuous operation, certain functions on the hoisting machine are required to be interrelated, proper co-ordination shall be ensured by suitable interlocks. For a group of hoisting machines working together in a co-ordinated manner and having more than one controller, provision shall be made to co-ordinate the operations of the controllers as necessary.

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Where a failure of a mechanical brake actuator can result in the brake being applied when the associated machine actuator is energized and a hazardous condition can result, interlocks shall be provided to switch off the machine actuator.

**9.3.5 Reverse current braking** Where reverse current braking is used on a motor, effective measures shall be taken to avoid the motor starting in the opposite direction at the end of braking where that reversal can cause a hazardous condition or damage to the machine or to the load. For this purpose, the use of a device operating exclusively as a function of time shall not be allowed.

This requirement is only applicable on hoisting machines in automatic operation.

**9.3.6 Inverter operation (variable frequency) control** For inverter operation of a hoisting machine, following safety measures shall be taken:

— for application in an area where heat generation of braking resistor and the like may result in a probability of a hazard, it is to be constructed so as to prevent fire spread (e.g. for a braking resistor as being in heating source, covering the periphery with incombustible material to avoid external fire spread, or attaching a protective device such as thermostat to interrupt the current continuity during an abnormal occurrence);

— for preventing heat generation due to being in continuous state of excitation, which may occur at the event of inverter failure caused by rupture of main circuit element, failure of micro-processor or relevant circuit and the like, to provide a system that surely disconnects the power supply to the inverter (e.g. interrupting the power supply with the crane switch);

— to take a measure, in the event of a trip (stop for protection purpose) by inverter operation control, to prevent drop or run-away by the torque reduction due to interruption of inverter output (e.g. detecting the output reduction of inverter to actuate the mechanical brake);

— where avoiding a trip by inverter operation control can result in a hazardous condition, not to intentionally avoid the trip (e.g. where lengthening of slow-down distance at deceleration can result in collision by overrunning, not to actuate stall limiting function of overcurrent trip prevention);

— after tripping by inverter operation, where the hoisting machine can result in a hazardous condition, not to reset automatically (see **9.2.5.1**) (e.g. not to actuate the alarm retry function or repeating function for transient voltage drop or transient supply interruption).

**9.3.6.2 Operation by inverter control** Where operating a hoisting machine by inverter control, it should be permitted as follows:

— for brake holding, not to depend on electric braking function by inverter control but to perform by using mechanical brake;

— to take a measure to lower affect of electromagnetic hindrance to peripheral devices;

— to take a measure to prevent the hoisting machine from an operation exceeding permitted speed (e.g. to avoid attaining a speed over the permitted speed by upper frequency limiting function of the inverter even if the speed command is input excessively.

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### 9.4 Control functions in the event of failure

**9.4.1 General requirements** Where failures or disturbances in the electrical equipment can cause a hazardous condition or damage to the hoisting machine, appropriate measures shall be taken to minimize the probability of such hazards occurring. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application (see **4.1**).

Measures to reduce those risks include, but not limited to:

— protective devices on the hoisting machine (e.g. interlock guards, trip devices);

— protective interlocking of the electrical circuit;

— use of proven circuit techniques and components (see **9.4.2.1**);

— provision of partial or complete redundancy (see **9.4.2.2**) or diversity (see **9.4.2.3**);

— provision for functional tests (see **9.4.2.4**).

In general, only single failures are to be regarded. In the event of higher levels of risk, it may be necessary to ensure that more than one failure cannot result in a hazardous condition.

#### 9.4.2 Measures to minimize risk in the event of failure

**9.4.2.1 Use of proven circuit techniques and components** These measures include, but are not limited to:

— bonding of control circuits to the protective bonding circuit for operational purposes (see **9.4.3.1**);

— connection of control devices in accordance with **9.1.4**;

— stopping by de-energizing (see **9.2.2**):

— the switching of all live conductors to the device being controlled (see **9.4.3.1**);

— the use of switching devices having positive (or direct) opening action (see **JIS C 8201-5-1**);

— circuit design to reduce the possibility of failures causing undesirable operations.

**9.4.2.2 Provisions for redundancy** By providing partial or complete redundancy it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous condition. Redundancy can be effective in normal operation (i.e. on-line redundancy), or designed as special circuits that take over the protective function (i.e. off-line redundancy) only where the operating function fails.

Where off-line redundancy which is not active during normal operation is used, suitable measures shall be taken to ensure that those control circuits are available when required.

**9.4.2.3 Use of diversity** The use of control circuits having different principles of operation or using different types of devices may reduce the probability of hazards resulting from faults and/or failures. Examples include:

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— the combination of normally open and normally closed contacts operated by interlocking guards;

— the use of different types of control circuit components in the circuit;

— the combination of electromechanical and electronic circuits in redundant configurations;

— the combination of electrical and non-electrical systems (e.g. mechanical, hydraulic, pneumatic) may perform the redundant function and provide the diversity.

**9.4.2.4 Functional tests** Functional tests may be carried out automatically by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also **18.2** and **19.4**).

**9.4.3 Protection against maloperation due to earth faults, voltage interruptions, and loss of circuit continuity**

**9.4.3.1 Earth faults** Earth faults on any control circuit shall not cause unintentional starting, potentially hazardous motions, or prevent stopping of the hoisting machine.

In order to fulfil this requirement, bonding to the protective bonding circuit may be provided in accordance with **8.2**, and the devices may be connected as described in **9.1.4**. Control circuits fed from a transformer and not connected to the protective bonding circuit shall be provided with an insulation monitoring device that either indicates an earth fault, or interrupts the circuit automatically after an earth fault.

Where the control circuit is directly connected between the phase conductors of the supply or between a phase conductor and a neutral conductor that is not earthed, or is earthed through a high impedance, multi-pole control switches that interrupt all live conductors shall be used for START or STOP of those hoisting machine functions that can cause a hazardous condition or damage to the hoisting machine in the event of unintentional starting or failure to stop.

**9.4.3.2 Voltage interruptions** The requirements detailed in **7.5** shall apply.

Where the control system uses a memory device(s), proper functioning in the event of power failure shall be ensured (e.g. by using a non-volatile memory) to prevent any loss of memory that can result in a hazardous condition.

**9.4.3.3 Loss of circuit continuity** Where the loss of continuity of safety-related control circuits depending upon sliding contacts can result in a hazardous condition, appropriate measures shall be taken (e.g. by duplication of the sliding contacts).

**9.4.4 Protection against maloperation of a motion control system** In a closed loop motion control system for an electric motor(s), inadmissible control deviations which can cause a hazardous condition shall be detected automatically, the power to the motor(s) shall be switched off by a category 0 stop, and the mechanical brake(s) shall be applied (see **15.7**).

In a hydraulic or pneumatic drive employing an energy converter (e.g. hydraulic pump, compressor, etc.), the motion of the hoisting machine shall be stopped if the electrical supply to the energy converter fails.

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**9.5 Safety-related control circuits** Safety-related control circuits which detect excessive travel, speeds and/or loads which can cause a hazardous condition, or cause damage to the hoisting machine or to the load shall, upon the detection of such a condition, initiate a stop, the category of which shall be determined by the risk assessment of the hoisting machine and its application.

There shall be functional tests according to **9.4.2.4**.

## 10 Operator interface and hoisting machine mounted control devices

### 10.1 General

**10.1.1 General device requirements** This clause **10** contains requirements for devices mounted outside or partially outside control enclosures. As far as is practicable, those devices shall be selected, mounted, and identified or coded in accordance with **JIS C 0447** and **JIS C 0448**.

**10.1.2 Location and mounting** As far as is practicable, hoisting machine mounted control devices shall be:

— readily accessible for service and maintenance;

— mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

The actuates of hand-operated control devices shall be selected and installed as that:

— they are not less than 0.6 m above the servicing level and are within easy reach of the normal working position of the operator;

— the operator is not placed in a hazardous situation when operating them;

— the possibility of inadvertent operation is minimized.

**10.1.3 Protection** Where mounted as intended, operator interface and hoisting machine mounted control devices shall withstand the stresses of expected use. The degree of protection (see **JIS C 0920**), together with other appropriate measures, shall afford protection against:

— the effects of aggressive liquids, vapours, or gases found in the physical environment;

— the ingress of contaminants (e.g. swarf, dust, particulate matter).

In addition, the operator interface control devices shall have a minimum degree of protection against direct contact of IPXXD (see **JIS C 0920**).

**10.1.4 Position sensors** Position sensors (e.g. position switches, proximity switches) shall be so arranged that they will not be damaged in the event of overtravel.

Position sensors used in circuits with safety-related functions either shall have positive (or direct) opening action (see **JIS C 8201-5-1**) or shall provide similar reliability.

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**10.1.5 Portable and pendant control stations** Portable and pendant operator control stations and their control devices shall be so selected and arranged as to minimize the possibility of inadvertent hoisting machine operations caused by shocks and vibrations (e.g. if the operator control station is dropped or strikes an obstruction).

### 10.2 Push-buttons

**10.2.1 Colours** Push-button actuators shall be colour-coded in accordance with table 2.

The colours for START/ON actuators should be WHITE, GREY or BLACK with a preference for WHITE. GREEN is also permitted. RED shall not be used.

The colour RED shall be used for emergency stop and emergency switching off actuators.

The colour for STOP/OFF actuators should be BLACK, GREY, or WHITE with a preference for BLACK. GREEN shall not be used. RED is also permitted, but it is recommended that RED is not used near an emergency stop and/or emergency switching off device.

WHITE, GREY, or BLACK are the preferred colours for push-button actuators that alternately act as START/ON and STOP/OFF push-buttons. The colours RED, YELLOW, or GREEN shall not be used (see also **9.2.6**).

WHITE, GREY, or BLACK are the preferred colours for push-button actuators that cause operation while they are actuated and cease the operation when they are released (e.g. hold-to-run). The colours RED, YELLOW, or GREEN shall not be used.

Reset push-buttons shall be BLUE, WHITE, GREY, or BLACK. Where they also act as a STOP/OFF button, the colours WHITE, GREY, or BLACK are preferred with the main preference being for BLACK. GREEN shall not be used.

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**Table 2 Colour-coding for push-button actuators and their meanings**

| Colour | Meaning | Explanation | Examples of application |
|---|---|---|---|
| RED | Emergency | Actuate in the event of a hazardous condition or emergency | Emergency stop;<br>Initiation of emergency function<br>(see also **10.2.1**) |
| YELLOW | Abnormal | Actuate in the event of an abnormal condition | Intervention to suppress abnormal condition;<br>Intervention to restart an interrupted automatic cycle. |
| GREEN | Normal | Actuate to initiate normal conditions | (See **10.2.1**) |
| BLUE | Mandatory | Actuate for a condition requiring mandatory action | Reset function |
| WHITE | No specific meaning assigned | For general initiation of functions except for emergency stop<br>(see also note) | START/ON (preferred)<br>STOP/OFF |
| GREY | | | START/ON (preferred)<br>STOP/OFF |
| BLACK | | | START/ON<br>STOP/OFF (preferred) |
| NOTE: Where an additional means of coding (e.g. shape, position, texture) is used for the identification of push-button actuators, then the same colour WHITE, GREY, or BLACK may be used for various functions (e.g. WHITE for START/ON and for STOP/OFF actuators). | | | |

**10.2.2 Markings** In addition to the functional identification as described in **17.3**, it is recommended that push-buttons be marked, near to or preferably directly on the actuators, with the following symbols:

| Meaning | START or ON | STOP or OFF | Push-buttons acting alternately as START or STOP buttons and as ON or OFF buttons | Push-buttons acting as START or ON buttons when pressed and as STOP or OFF buttons when released (i.e. hold-to-run) |
|---|---|---|---|---|
| Symbol No. | **IEC 60417-2-5007** | **IEC 60417-2-5008** | **IEC 60417-2-5010** | **IEC 60417-2-5011** |
| Graphic symbol |  |  |  |  |

## 10.3 Indicator lights and displays

**10.3.1 Modes of use** Indicator lights and displays serve to give the following types of information:

— indication: to attract the operator's attention or to indicate that a certain task should be performed. The colours RED, YELLOW, GREEN, and BLUE are normally used in this mode;

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— confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colours BLUE and WHITE are normally used in this mode and GREEN may be used in some cases.

**10.3.2 Colours** Unless otherwise agreed between the supplier and the user, indicator (pilot) light lenses shall be colour-coded with respect to the condition (status) of the hoisting machine in accordance with table 3. Alternative meanings may be assigned (see **JIS C 0448**) in accordance with one of the following criteria:

— the safety of persons and the environment;

— the state of the electrical equipment.

**Table 3 Colours for indicator lights and their meanings with respect to the condition of the hoisting machine**

| Colour | Meaning | Explanation | Action by operator |
|---|---|---|---|
| RED | Emergency | Hazardous condition | Immediate action to deal with hazardous condition (e.g. by operating emergency stop) |
| YELLOW | Abnormal | Abnormal condition; Impending critical condition | Monitoring and/or intervention (e.g. by reestablishing the intended function) |
| GREEN | Normal | Normal condition | Optional |
| BLUE | Mandatory | Indication of a condition that requires action by the operator | Mandatory action |
| WHITE | Neutral | Other conditions, may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE | Monitoring |

**10.3.3 Flashing lights** For further distinction or information and especially to give additional emphasis, flashing lights may be used for the following purposes:

— to attract attention;

— to request immediate action;

— to indicate a discrepancy between the command and actual states;

— to indicate a change in process (flashing during transmission).

It is recommended that higher frequency flashing lights be used for higher priority information (see **JIS C 0448** for recommended flashing rates and pulse/pause ratios).

**10.4 Illuminated push-buttons** Illuminated push-button actuators shall be colour-coded in accordance with tables 2 and 3. Where there is difficulty in assigning an appropriate colour, WHITE shall be used. The colour RED for the emergency stop actuator shall not depend on the illumination of its light.

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**10.5 Rotary control devices** Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be sufficient.

**10.6 Start devices** Actuators used to initiate a start function or the movement of hoisting machine elements (e.g. trolleys) shall be constructed and mounted so as to minimize inadvertent operation. However, mushroom-type actuators may be used for two-hand control.

**10.7 Devices for emergency stop and/or emergency switching off**

**10.7.1 General** A device for emergency stop or for emergency switching off shall be located at each operator control station (exception: see **9.2.7.3**).

**10.7.1.1 Emergency stop** Where required, additional emergency stop devices shall be provided (e.g. near unprotected rope winches).

Where required emergency stop devices shall also be located outside the hoisting machine (e.g. operable at floor level in the case of overhead travelling cranes).

The stopping of all motion drives from floor level may be dispensed with for those drives of the hoisting machine which may cause additional hazards, for example on gantry cranes, it may be sufficient to stop the gantry motion. On mobile cranes such devices may not be required at floor level.

This function may be performed by one or more of the switching devices shown in figure 3 (i.e. switchgear for drives, crane-switch or crane-supply-switch).

**10.7.1.2 Emergency switching off** The crane-supply-switch may fulfil the function of an emergency switching off device.

The device shall be capable of being operated from an easily and quickly accessible location near to the hoisting machine, either directly, or remotely.

According to a risk assessment the provision of emergency switching off facilities may also be necessary for other locations in which live conductors may be exposed in normal service (see also **9.2.5.4.3** and **13.8.1**).

**10.7.2 Types** The types of devices for emergency stop and/or emergency switching off include:

— a push-button operated switch;

— a pull-cord operated switch;

— a pedal-operated switch without a mechanical guard.

The devices shall be of the self-latching type and shall have positive (direct) opening action (see **JIS C 8201-5-1**).

**10.7.3 Restoration of normal function after emergency stop and/or emergency switching off** It shall not be possible to restore a circuit for an emergency operation until the device for that emergency operation has been manually reset. Where several devices for emergency operations are provided in a circuit, it shall not be possible to restore that circuit until all devices for emergency operations that have been operated have been reset.

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**10.7.4 Actuators** Actuators of devices for emergency stop and/or emergency switching off shall be coloured RED. The background immediately around the actuator shall be coloured YELLOW. The actuator of a push-button operated emergency stop and/or emergency switching off device shall be of the palm or mushroom head type.

**10.8 Displays** Displays (e.g. visual display units, alarm annunciators) shall be selected and installed in such a manner as to be visible from the normal position of the operator. Where displays are intended to be warning devices, it is recommended that they be of the flashing or rotary type and be provided with an audible warning device.

## 11 Electronic equipment

**11.1 General** This clause applies to all types of electronic devices, including programmable electronic equipment, subassemblies, printed circuit boards, devices, and components.

### 11.2 Basic requirements

**11.2.1 Inputs and outputs** An indication of the status of all digital inputs and outputs should be provided.

**11.2.2 Equipotential bonding** All (remote or local) input/output racks, processor racks, and power supplies shall be electrically bonded together in accordance with the supplier's specifications and connected to the protective bonding circuit (see **8.2.3**).

Where it is necessary for operational purposes for some equipment to be isolated from the protective bonding circuit, such equipment may be excluded from this requirement in accordance with clause **8**.

### 11.3 Programmable equipment

**11.3.1 Programmable controllers** Programmable controllers shall conform to relevant JIS standards (**JIS B 3501** and **JIS B 3502**).

**11.3.2 Memory retention and protection** Means shall be provided to prevent memory alteration by unauthorized persons and the requirements detailed in **9.4.3.2** shall apply.

**11.3.3 Software verification** Equipment using reprogrammable logic shall have means for verifying that the software is in accordance with the relevant programme documentation.

**11.3.4 Use in safety-related functions** Programmable electronic equipment shall not be used for emergency stop and/or emergency switching off functions (see **9.2.5.4**).

For all other safety-rated stop functions, the use of hardwired electromechanical components is preferred (i.e. the function should not depend on the operation of programmable electronic equipment). Where programmable electronic equipment is used for such functions, then appropriate measures in accordance with **9.4** shall be employed.

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These requirements shall not preclude the use of programmable electronic equipment for monitoring, testing, or backing-up such functions, but this equipment shall not prevent the correct operation of those functions.

NOTE : In situations where a significant hazard can occur due to maloperation of the control system, it is currently difficult to determine with any degree of certainty that reliance on correct operation of a single-channel of programmable electronic equipment can be assured. Until such a time that this situation can be resolved, it is inadvisable to rely solely on the correct operation of such a single-channel device.

## 12 Controlgear: location, mounting, and enclosures

**12.1 General requirements** All controlgear shall be located and mounted so as to facilitate the following matters:

— its accessibility and maintenance;

— its protection against the external influences or conditions under which it is intended to operate;

— operation and maintenance of the hoisting machine and its associated equipment.

### 12.2 Location and mounting

**12.2.1 Accessibility and maintenance** All items of controlgear shall be placed and oriented so that they can be identified without moving them or the wiring. For items that require checking for correct operation or that are liable to need replacement, these actions should be possible without dismantling other equipment or parts of the hoisting machine (except opening doors or removing covers). Terminals not associated with controlgear shall also conform to these requirements.

All controlgear shall be mounted so as to facilitate its operation and maintenance from the front. Where a special tool is necessary to remove a device, such a tool shall be supplied. Where access is required for regular maintenance or adjustment, the relevant devices shall be located between 0.4 m and 2.0 m above the servicing level. It is recommended that terminals be at least 0.2 m above the servicing level and be so placed that conductors and cables can be easily connected to them.

No devices except devices for operating, indicating, measuring, and cooling shall be mounted on doors and on normally removable covers.

Where more than one control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation (see **14.4.5** and **17.5**).

Plug-in devices that are handled during normal operation shall be provided with non-interchangeable features where the lack of such a facility can result in malfunctioning.

Plug/socket combinations that are handled during normal operation shall be located and mounted so as to provide unobstructed access.

Test points, where provided, shall be:

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— mounted so as to provide unobstructed access;

— clearly marked to correspond with the documentation (see **18.3**);

— adequately insulated;

— sufficiently spaced for connection of the test equipment or means.

**12.2.2 Physical separation or grouping** Non-electrical parts and devices, not directly associated with the electrical equipment, shall not be located within enclosures containing controlgear. Devices such as solenoid valves should be separated from the other electrical equipment (e.g. in a separate compartment).

Control devices mounted in the same location and connected only to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.

Terminals shall be separated into groups for:

— power circuits;

— associated control circuits;

— other control circuits, fed from external sources (e.g. for interlocking).

The groups may be mounted adjacently, provided that each group can be readily identified (e.g. by markings, by use of different sizes, by use of barriers or by colours).

When arranging the location of devices including interconnections, the clearances and creepage distances specified for them shall be maintained, taking into account the external influences or conditions of the physical environment (see **JIS C 0704**).

**12.2.3 Heating effects** Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted limit.

**12.3 Degrees of protection** The protection of controlgear against ingress of solid foreign objects and of liquids shall be adequate, taking into account the external influences under which the hoisting machine is intended to operate (i.e. the location and the physical environmental conditions), and shall be sufficient against dust, coolants, and swarf.

NOTE 1 The degrees of protection against ingress of water are covered by **JIS C 0920**. Additional protective measures may be necessary against other liquids.

In electrical and enclosed electrical operating areas switchgear and controlgear shall have protection of at least IP1X.

NOTE 2 For protection against direct contact in electrical and enclosed electrical operating areas see **6.2**.

Switchgear and controlgear outside electrical or enclosed electrical operating areas shall have protection of at least IP2X. Excepting that IP2X need not be achieved. Where removable collectors on collector wire or collector bar systems are used and the measures of **6.2.5** are applied.

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NOTE 3 Some examples of applications, together with the degree of protection typically provided by their enclosures, are listed below:

— ventilated enclosure, containing only motor starter resistor and other large size equipment: IP10

— ventilated enclosure, containing other equipment: IP32

— enclosure used in general industry: IP32, IP43 and IP54

— enclosure used in locations that are cleaned with low pressure water jets (hosing): IP55

— enclosure providing protection against fine dust: IP65

— enclosure containing slip ring assemblies: IP2X

Depending upon the conditions where installed, another degree of protection may be appropriate.

**12.4 Enclosures, doors and openings** Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses, as well as the effects of humidity that are likely to be encountered in normal service.

Fasteners used to secure doors and covers should be of the captive type. Windows provided for viewing internally mounted indicating devices shall be of a material suitable to withstand mechanical stress and chemical attack (e.g. toughened glass, polycarbonate sheet of 3 mm thickness).

It is recommended that enclosure doors be not wider than 0.9 m and have vertical hinges, preferably of the lift off type, with an angle of opening of at least 95°.

The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical effects of corrosive liquids, vapours, or gases found in the environment of the hoisting machine. The means used to maintain the degree of protection of an enclosure on doors, lids, and covers that require opening or removal for operation or maintenance shall:

— be securely attached to either the door/cover or the enclosure;

— not deteriorate due to removal or replacement of the door or the cover, and so impair the degree of protection.

All openings in the enclosure, including those towards the floor or foundation or to other parts of the hoisting machine, shall be closed by the supplier(s) in a manner ensuring the degree of protection specified for the equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening may be provided in the base of enclosures within the hoisting machine so that moisture due to condensation may drain away.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate.

This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

Where there are holes in an enclosure for mounting purposes, care shall be taken so that after mounting, the holes do not impair the required protection.

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Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or harmful effect to an enclosure material:

— shall be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as may be generated; and

— shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also **12.2.3**); or

— shall be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

### 12.5 Access to controlgear

**12.5.1 Gangways** The minimum dimensions of gangways in front of and between switchgear and controlgear shall be in accordance with clause **481.2.4** of **JIS C 0364-4-481** except, for structural reasons (e.g. relation between the hoisting machine and the building) the vertical clearance may be reduced to not less than 1 400 mm for lengths not exceeding 1 000 mm.

NOTE : The dimensions given in **JIS C 0364-4-481, 481.2.4** are recommended minima. It may be necessary to adopt higher values for other considerations such as suitable working positions, escape facilities, mobility of the hoisting machine.

**12.5.2 Access to gangways** Operating and maintenance gangways of a length of 20 m and longer shall be accessible from both ends. For gangways shorter than 20 m, but exceeding 6 m, access from both ends is recommended.

**12.5.3 Doors** Doors in gangways and for access to electrical operating areas shall:

— be at least 0.7 m wide and 2.0 m high;

— open outwards;

— have a means (e.g. panic bolts) to allow opening from the inside without the use of a key or tool.

**12.5.4 Gangway and door restrictions** Where the dimensions of gangways and/or doors have to be reduced, for example at bulkheads necessary for stiffening in box girders, the clear height may be reduced to not less than 1 400 mm and the clear width to not less than 600 mm at these points.

The means provided for protection against unintended contact with live parts along the gangway may not be sufficient for the areas immediately adjacent to these restrictions. Additional means can be required at these points (see **6.2**).

## 13 Conductors and cables

**13.1 General requirements** Conductors and cables shall be selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences [e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation) fire hazards] that can exist.

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These requirements do not apply to the integral wiring of assemblies, subassemblies, and devices that are tested in accordance with **JIS C 8480** annex 2 or other relevant **JIS** standard.

Where cables are installed on hoisting machines used in the open air (e.g. outside buildings or other protective structures), they shall be suitable for outdoor use (e.g. UV-resistant, adequate temperature range), or be appropriately protected.

**13.2 Conductors** In general, conductors shall be of copper. Conductors of any other material shall have a nominal cross-sectional area such that, carrying the same current, the maximum conductor temperature shall not exceed the value given in table 4. Where aluminium is used, the cross-sectional area shall be at least 16 $mm^2$.

Although class 1 conductors are primarily intended for use between rigid, non-moving parts, they may also be used where minimal flexing occurs provided that the cross-sectional area is less than 0.5 $mm^2$. All conductors that are subject to frequent movement (e.g. one movement/hour of machine operation) shall have flexible stranding of class 5 or class 6 (see annex B table 4).

**Table 4 Maximum allowable conductor temperatures under normal and short-circuit conditions**

| Type of insulation | Maximum temperature under normal conditions<br>°C | Ultimate short-time conductor temperature under short-circuit conditions<br>°C * |
|---|---|---|
| Polyvinyl chloride (PVC) | 70 | 160 |
| Rubber | 60 | 200 |
| Cross-linked polyethylene (XLPE) | 90 | 250 |
| Ethylene propylene compound (EPR) | 90 | 250 |
| Silicone rubber (SiR) | 180 | 350 |

NOTES 1 For ultimate short-time conductor temperatures greater than 200 °C, copper conductors shall be either silver plated or nickel plated because neither tinned nor bare conductors are suitable above 200 °C.

2 Higher maximum conductor temperatures than those given in table 4 may be used according to the data given by the cable manufacturers. The operating conditions (e.g. the surface temperature of the cable) have to be taken into account.

Information: For the ultimate conductor temperature, the "Electrical Appliance" and **JIS S 0168** have regulation or specification different from this table.

*: These values are based on the assumption of adiabatic behaviour for a period of not more than 5 s.

**13.3 Insulation** The types of insulation include (but are not limited to):

— polyvinyl chloride (PVC);

— rubber, natural and synthetic;

— silicone rubber (SiR);

— mineral;

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— cross-linked polyethylene (XLPE);

— ethylene propylene compound (EPR).

Where the insulation of conductors and cables (e.g. PVC) can constitute hazards due to the propagation of a fire or the emission of toxic or corrosive fumes, guidance from the cable supplier should be sought. It is important to give special attention to the integrity of a circuit having a safety-related function.

The dielectric strength of the insulation shall be adequate for the test voltage required with a minimum of 2 000 V a.c. for 5 min duration for cables operating at voltages higher than 50 V a.c. or 120 V d.c. For separate PELV circuits, the dielectric strength shall be adequate for the test voltage of 500 V a.c. for a duration of 5 min (see **JIS C 0364-4-41** class III equipment).

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

**13.4 Current-carrying capacity in normal service** The current-carrying capacity of conductors and cables is determined by both:

— the maximum allowable conductor temperature under the highest possible steady state current or the thermal equivalent r.m.s. current for intermittent duty applications (see annex B clause **B.2**);

— the ultimate allowable short-time conductor temperature under short-circuit conditions.

The cross-sectional area of a conductor shall be such that, under those conditions above, the conductor temperature does not exceed the value given in table 4, unless otherwise specified by the cable manufacturer. The current carrying capacities for PVC insulated wiring between enclosures and individual items of equipment under steady state conditions are given in table 5. For the selection of conductors and cables for intermittent duty applications, see annex B clause **B.2** for the calculation of the thermal equivalent r.m.s. current.

The conductor cross-sectional area may be selected in accordance with **JIS C 0364-5-523**.

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**Table 5 Current carrying capacity (*Iz*) of PVC insulated copper conductors or cables under steady state conditions in an ambient air temperature of +40 °C for different methods of installation**

| Cross-sectional area | Installation method (see **B.1.2**) | | | |
|---|---|---|---|---|
| | B1 | B2 | C | E |
| (mm²) | Current carrying capacity *Iz* A | | | |
| 0.75 | 7.6 | — | — | — |
| 1.0 | 10.4 | 9.6 | 11.7 | 11.5 |
| 1.5 | 13.5 | 12.2 | 15.2 | 16.1 |
| 2.5 | 18.3 | 16.5 | 21 | 22 |
| 4 | 25 | 23 | 28 | 30 |
| 6 | 32 | 29 | 36 | 37 |
| 10 | 44 | 40 | 50 | 52 |
| 16 | 60 | 53 | 66 | 70 |
| 25 | 77 | 67 | 84 | 88 |
| 35 | 97 | 83 | 104 | 114 |
| 50 | — | — | 123 | 123 |
| 70 | — | — | 155 | 155 |
| 95 | — | — | 192 | 192 |
| 120 | — | — | 221 | 221 |
| Electronic (pairs) | | | | |
| 0.2 | — | — | 4.0 | 4.0 |
| 0.3 | — | — | 5.0 | 5.0 |
| 0.5 | — | — | 7.1 | 7.1 |
| 0.75 | — | — | 9.1 | 9.1 |

NOTES
1 For ambient temperatures other than 40 °C, correct the current carrying capacities by using values given in annex B table 1.
2 For grouped cables/conductors, see annex B table 2 for derating factors.
3 For multicore cables up to 10 mm², see annex B table 3 for derating factors.
4 These values are not applicable to flexible cables wound on drums (see **13.7.3**).
5 For the current-carrying capacity of 600 V PVC insulated cable defined in **JIS C 3307**, see **JIS B 6015** information table 4.
6 For the current-carrying capacities of other cables, see **JIS C 0364-5-523**.

**13.5 Voltage drop** The voltage drop from the crane-supply-switch to the motors or, in the case of a converter driven motor, to the input side of the converter, shall not exceed 5 % of the nominal voltage under normal operating conditions. In order to conform to this requirement, it may be necessary to use conductors having a larger cross-sectional area than that derived from table 5.

NOTE : If more information is not available, the voltage drop may be calculated by using the starting current of the largest drive combined with the nominal current of the next largest drive. When there is more than one

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hoisting machine on a common power supply, a simultaneity factor may be used according to the given service conditions (see annex B).

**13.6 Minimum cross-sectional area** To ensure adequate mechanical strength, the cross-sectional area of conductors should not be less than as shown in table 6. However, where it is considered necessary, conductors with smaller cross-sectional areas than shown in table 6 may be used in equipment, provided adequate mechanical strength is achieved by other means, and proper functioning is not impaired.

**Table 6 Minimum cross-sectional areas of copper conductors**

Unit : $mm^2$

| Location | Applications | Description of conductors and cables | | | | |
|---|---|---|---|---|---|---|
| | | Single core stranded | Single core solid | Two cores shielded | Two cores not shielded | Three or more cores shielded or not shielded |
| Outside enclosures | Non-flexing power wiring | 1 | 1.5 | 0.75 | 0.75 | 0.75 |
| | Connections to machine parts subject to frequent movement | 1 | — | 1 | 1 | 1 |
| | Connections in control circuits | 1 | 1.5 | 0.3 | 0.5 | 0.3 |
| | Data communication wiring | — | — | — | — | 0.08 |
| Inside enclosures | Non-flexing power wiring | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| | Connections in control circuits | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Data communication wiring | — | — | — | — | 0.08 |

## 13.7 Flexible cables

**13.7.1 General** Flexible cables shall have class 5 or class 6 conductors (see annex B table 4).

Cables that are subjected to severe duties shall be of adequate construction to protect against:

— abrasion due to mechanical handling and dragging across rough surfaces;

— kinking due to operation without guides;

— stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTES 1 Cables for such conditions are in accordance with the manufacturer's specification.

2 The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

**13.7.2 Mechanical rating** The cable handling system of the hoisting machine shall be so designed to keep the tensile stress of the conductors as low as is practicable during hoisting machine operations. Where copper conductors are used, the tensile

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stress shall not exceed 15 N/mm² of the copper cross-sectional area. Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used and the allowed maximal tensile strength should be agreed with the cable manufacturer.

The allowed maximum stress of conductors of flexible cables with material other than copper should be agreed with the cable manufacturer.

NOTE : The following conditions affect the tensile stress of the conductors:

— acceleration forces;

— speed of motion;

— dead (hanging) weight of the cables;

— method of guiding;

— design of cable drum system.

**13.7.3 Current carrying capacity of cables wound on drums** Cables to be wound on drums shall be selected with conductors having a cross-sectional area such that, when fully wound on the drum and carrying the normal service load, the maximum allowable conductor temperature is not exceeded.

For cables of circular cross-sectional area installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with table 7 (see also **IEC 60621-3**, clause **44**).

NOTE : The current-carrying capacity of cables in free air can be found in manufacturer's specifications.

**Table 7 Derating factors for cables wound on drums**

| Drum type | Number of layers of cable | | | | |
|---|---|---|---|---|---|
| | Any number | 1 | 2 | 3 | 4 |
| Cylindrical ventilated | — | 0.85 | 0.65 | 0.45 | 0.35 |
| Radial ventilated | 0.85 | — | — | — | — |
| Radial non-ventilated | 0.75 | — | — | — | — |

NOTES 1 A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and if the flanges have suitable apertures, as ventilated.

2 A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have ventilating apertures.

3 It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This may result in other factors being used.

## 13.8 Collector wires, collector bars and slip-ring assemblies

**13.8.1 Protection against direct contact** Collector wires, collector bars and slip-ring assemblies shall be installed or enclosed in such a way that, during normal access to the hoisting machines, (for example via gangways along a crane track or along a crane girder,) protection against direct contact shall be achieved by the application of one of the following protective measures:

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— protection by partial insulation of live parts. This is the preferred measure;

— protection by enclosures or barriers of at least IP2X (see **JIS C 0364-4-41, 412.2**).

Horizontal top surfaces of barriers or enclosures that are readily accessible shall provide a degree of protection of at least IP4X (see **JIS C 0364-4-41, 412.2.2**).

Where the required degree of protection is not achieved, one of the following additional protective measures shall be applied:

a) protection by placing live parts out of reach in combination with emergency switching off in accordance with **9.2.5.4.2** (see **JIS C 0364-4-41, 412.4**) or where this is not practicable.

b) protection by compliance with the limits (derived from **JIS B 9707**) given in figures 5a or 5b or 5c. This measure is intended to be used in areas where only skilled or instructed persons have access and where special conditions exist (e.g. hot area of steel mills or in chemical plants).

NOTE : Examples of obstacles located above unprotected collector wires or collector bars are guard-rails, mesh-screens.

Collector wires and collector bars shall be so placed and/or protected as follows:

— prevent contact, especially for unprotected collector wires and collector bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains;

— prevent damage from a swinging load;

— where provided neither enclosure nor insulation cover to the crane or trolley wire to prevent electric shock by trolley wire, not to locate a gangway, stair or platform at a position less than 2.3 m above and 1.2 m sideways the trolley wire;

— those exceeding 600 V a.c. or exceeding 750 V d.c., where provided neither enclosure nor installation cover to the crane or trolley wire to prevent electric shock by the trolley wire, shall be contained in a dedicated pit or duct.

Where the required degree of protection provided for collector wires or collector bars is not effective (e.g. adjacent to current collectors) additional means shall be provided (e.g. additional obstacles).

If circuits of different crane-disconnectors are run through collector wires, collector bars or slip-ring assemblies, each subcircuit system shall be protected against direct contact with a degree of protection of at least IP2X or IPXXB (see **JIS C 0920**).

**13.8.2 Protective conductor circuit** Where collector wires, collector bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation. Therefore, the protective conductor (PE) and the neutral conductor (N) shall each use a separate collector wire, collector bar or slip-ring. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (e.g. duplication of the current collector, continuity monitoring).

**13.8.3 Protective conductor current collectors** Protective conductor current collectors shall have a shape or construction so that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type.

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Unit: mm

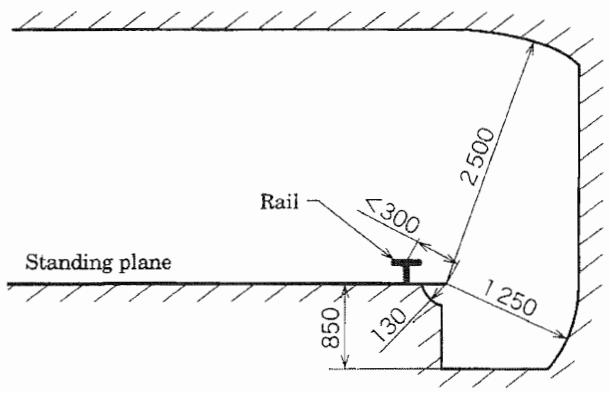


**Figure 5a Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is less than 300 mm**

Unit: mm

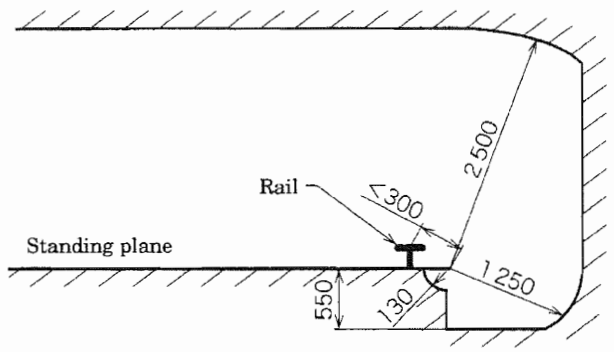


**Figure 5b Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is at least 300 mm**

Unit: mm

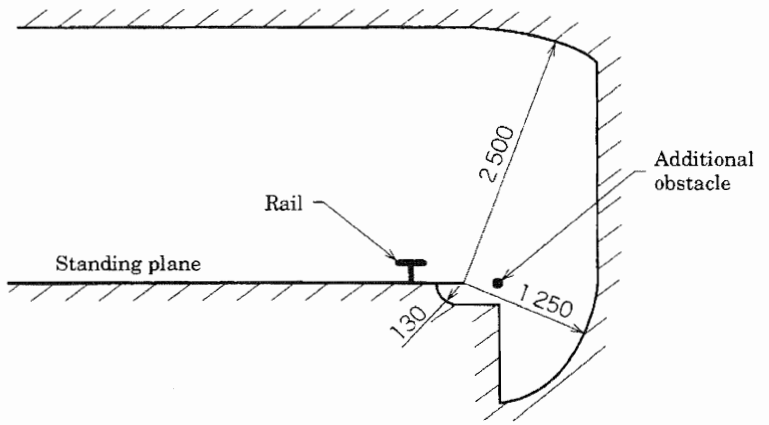


**Figure 5c Limit of arm's reach in cases of using additional obstacles**

**Figure 5 Limits of arm's reach**

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**13.8.4 Removable current collectors with a disconnector function** Removable current collectors having a disconnector function shall be so designed that the protective conductor circuit is interrupted only after the live conductors have been disconnected, and the continuity of the protective conductor circuit is re-established before any live conductor is reconnected (see also **8.2.6**).

**13.8.5 Clearances in air** Clearances between the respective conductors, and between adjacent systems, of collector wires, collector bars, slip-ring assemblies and their current collectors shall be suitable for operation in pollution degree 3 conditions (see **JIS C 0704, 3.2.1**).

**13.8.6 Creepage distances** Creepage distances between the respective conductors, and between adjacent systems of collector wires, collector bars and slip-ring assemblies, and their current collectors shall be suitable for operation in pollution degree 3 conditions (see **JIS C 0704, 3.2.1**).

In abnormally dusty, moist or corrosive environments, the following creepage distance requirements apply:

— unprotected collector wires, collector bars, and slip-ring assemblies shall be equipped with insulators with a minimum creepage distance of 60 mm;

— enclosed collector wires, insulated multipole collector bars and insulated individual collector bars shall have a minimum creepage distance of 30 mm.

The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (e.g. deposits of conductive dust, chemical attack).

**13.8.7 Conductor system sectioning** Where collector wires or collector bars are arranged so that they can be divided into isolated sections, suitable design measures shall be employed to prevent the energization of adjacent sections by the current collectors themselves.

**13.8.8 Construction and installation of collector wire, collector bar systems and slip-ring assemblies** Collector wires, collector bars and slip-ring assemblies used for power circuits shall be grouped separately from those used for control circuits.

Collector wires, collector bars and slip-ring assemblies shall be capable of withstanding, without damage, the mechanical forces and thermal effects of short circuit currents.

Removable covers for collector wire and collector bar systems laid underground or underfloor shall be so designed that they cannot be opened by one person without the aid of a tool.

Where collector bars are installed in a common metal enclosure, the individual sections of the enclosure shall be bonded together and earthed at several points depending upon their length. Metal covers of collector bars laid underground or underfloor shall also be bonded together and earthed.

NOTE : For equipotential bonding or protective conductor connection to covers or coverplates of metal enclosures or underfloor ducts, the usual metal hinges are considered sufficient to ensure continuity.

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Underground and underfloor collector bar ducts shall have drainage facilities.

## 14 Wiring practices

### 14.1 Connections and routing

**14.1.1 General requirements** All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.

The means of connection shall be suitable for the cross-sectional areas and nature of the conductors being terminated. For aluminium or aluminium alloy conductors, particular consideration shall be given to the prevention of problems of electrolytic corrosion (see **13.2**).

The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective conductor shall be connected to one terminal connecting point.

Soldered connections shall only be permitted where terminals are provided that are suitable for soldering.

Terminals on terminal blocks shall be plainly identified to correspond with markings on the diagrams.

The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings.

Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.

Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection.

Identification tags shall be legible, permanent, and appropriate for the physical environment.

Terminal blocks shall be mounted and wired so that the internal and external wiring does not cross over the terminals (see **JIS C 2811**).

**14.1.2 Conductor and cable runs** Conductors shall be run from terminal to terminal without splices or joints.

Where it is impracticable to provide terminals in a junction box, (e.g. on hoisting machines having long flexible cables), splices or joints may be used.

Where it is necessary to connect and disconnect cables and cable assemblies, a sufficient extra length shall be provided for that purpose.

The terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors.

Wherever possible, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

**14.1.3 Conductors of different circuits** Conductors of different circuits may be laid side by side, may occupy the same duct (e.g. conduit, cable trunking system), or may be in the same multi-conductor cable, provided that the arrangement does not

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impair the proper functioning of the respective circuits. Where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or shall be insulated for the highest voltage to which any conductor within the same duct can be subjected.

## 14.2 Identification of conductors

**14.2.1 General requirements** Conductors shall be identifiable at each termination in accordance with the technical documentation (see clause **18**). Annex A question 30, may be used for agreement between supplier and user regarding a preferred method of identification.

Where colour-coding is used for identification of conductors, the following colours may be used:

BLACK, BROWN, RED, ORANGE, YELLOW, GREEN, BLUE (including LIGHT BLUE), VIOLET, GREY, WHITE, PINK, TURQUOISE.

NOTE : This list of colours is derived from **IEC 60757**.

It is recommended that, where colour is used for identification, the colour be used throughout the length of the conductor either by the colour of the insulation or by colour markers. An acceptable alternative may consist of additional identification at selected locations.

For safety reasons, the colour GREEN or the colour YELLOW should not be used where there is a possibility of confusion with the bicolour combination GREEN-AND-YELLOW (see **14.2.2**).

Colour identification using combinations of those colours listed above may be used provided there can be no confusion, and that GREEN or YELLOW is not used except in the bicolour combination GREEN-AND-YELLOW.

**14.2.2 Identification of the protective conductor** The protective conductor shall be readily distinguishable by shape, location, marking, or colour. When identification is by colour alone, the bicolour combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This colour identification is strictly reserved for the protective conductor.

For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15 mm length one of the colours covers at least 30 % and not more than 70 % of the surface of the conductor, the other colour covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position, or construction (e.g. a braided conductor), or where the insulated conductor is not readily accessible, colour coding throughout its length is not necessary, but the ends or accessible positions shall be clearly identified by the graphical symbol **IEC 60417-2-5019** or by the bicolour combination GREEN-AND-YELLOW.

**14.2.3 Identification of the neutral conductor** Where a circuit includes a neutral conductor identified by colour, the colour shall be LIGHT BLUE [see **JIS C 0446**, **3** (**2**)]. LIGHT BLUE shall not be used for identifying any other conductor where confusion is possible.

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Where identification by colour is used, bare conductors used as neutral conductors shall be either coloured by a LIGHT BLUE stripe, 15 mm to 100 mm wide in each compartment or unit or at each accessible position, or coloured LIGHT BLUE throughout their length.

**14.2.4 Identification of other conductors** Identifications of other conductors shall be by colour (either solid or with one or more stripes), number, alphanumeric, or a combination of colour and numbers or alphanumeric. When numbers are used, they shall be Arabic; letters shall be Roman (either upper or lower case).

It is recommended that insulated conductors be colour-coded as follows:

— BLACK: a.c. and d.c. power circuits;

— RED: a.c. control circuits;

— BLUE: d.c. control circuits;

— ORANGE: interlock control circuits supplied from an external power source.

Exceptions:

to the above are permitted where:

— individual devices are purchased complete with internal wiring;

— insulation is used that is not available in the colours required; or

— multiconductor cable is used, but not the bicolour combination GREEN-and-YELLOW.

**14.3 Wiring inside enclosures** Panel conductors (e.g. busbars) shall be supported where necessary to keep them in place. Non-metallic ducts shall be permitted only when they are made with a flame-retardant insulating material (see **JIS C 3665-1**).

It is recommended that electrical equipment mounted inside enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure (see also **12.2.1**). Where that is not possible and control devices are connected from the rear of the enclosure, access doors or swingout panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with **13.2** to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection (see also **8.2.3** and **12.2.1**).

Conductors and cables that do not run in ducts shall be adequately supported.

Terminal blocks or plug/socket combinations shall be used for control wiring that extends beyond the enclosure.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

**14.4 Wiring outside enclosures**

**14.4.1 General requirements** The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced (see **12.3**).

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**14.4.2 External ducts** Conductors and their connections external to the electrical equipment enclosure(s) shall be enclosed in suitable ducts (i.e. conduit or cable trunking systems) as described in **14.5**, except for suitably protected cables that may be installed without ducts and with or without the use of open cable trays or cable support means.

Fittings used with ducts or multiconductor cable shall be suitable for the physical environment.

Flexible conduit or flexible multiconductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the flexible multiconductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multiconductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches, and to other externally mounted devices. Where prewired devices (e.g. position switches, proximity switches) are supplied, the integral cable need not be enclosed in a duct.

**14.4.3 Connection to the hoisting machine and to moving elements on the hoisting machine** Connections to frequently moving parts shall be made using conductors in accordance with **13.2**. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining, particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp flexing. When this is achieved by the use of a loop, it shall have sufficient length to provide for a bending radius of the cable of at least 10 times the diameter of the cable.

Flexible cables of hoisting machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

— being run over by the hoisting machine itself;

— being run over by vehicles or other hoisting machines;

— coming into contact with the hoisting machine structure during movements;

— running in and out on cable baskets, or on or off cable drums;

— acceleration forces and wind forces on festoon systems or suspended cables;

— excessive rubbing by cable collector;

— exposure to excessive radiated heat.

The cable sheath shall be resistant to the normal wear that can be expected from movement and to the effects of atmospheric contaminants (e.g. oil, water, coolants, dust).

Where cables subject to movement are close to moving parts, a space of at least 25 mm shall be maintained between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

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The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when:

— being wound on and off cable drums; and

— approaching and leaving cable guidance devices.

Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

Devices serving to guide and carry a flexible cable shall be so designed that the inner bending radius at all points where the cable is bent is not less than the values given in table 8, unless otherwise agreed with the cable manufacturer, taking into account the permissible tension and the expected fatigue life.

**Table 8 Minimum permitted bending radii for the forced guiding of flexible cables**

| Application | Cable diameter or thickness of flat cable $d$ (mm) | | |
|---|---|---|---|
| | $d \leq 8$ | $8 < d \leq 20$ | $d > 20$ |
| Cable drums | $6d$ | $6d$ | $8d$ |
| Guide rollers | $6d$ | $8d$ | $8d$ |
| Festoon systems | $6d$ | $6d$ | $8d$ |
| All others | $6d$ | $6d$ | $8d$ |

The straight section between two bends in an S-shaped length or a bend into another plane shall be at least 20 times the diameter of the cable.

Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation. Flexible metallic conduit shall not be used for rapid or frequent movements except when specifically designed for that purpose.

**14.4.4 Interconnection of devices on the hoisting machine** Where several hoisting machine mounted switching devices (e.g. position sensors, push-buttons) are connected in series or in parallel, it is recommended that the connections between those devices be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, adequately protected, and shown on the relevant diagrams.

**14.4.5 Plug/socket combinations** Where equipment is removable, connections to it through a polarized plug/socket combination are permitted.

Plug/socket combinations shall be of adequate size and shall have sufficient contact pressure and a wiping action to ensure electrical continuity. Clearances between contacts shall be adequate for the voltages used and shall be maintained during insertion and removal of the connectors.

Plug/socket combinations shall be of such a type and so installed to prevent unintentional contact with live parts at any time even during insertion or removal of the connectors. PELV circuits are excepted from this requirement.

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Plug/socket combinations shall be so designed that a protective bonding circuit connection is made before any live connections are made, and is not disconnected until at live connections in the plug are disconnected (see also **6.2.4**) except those used in PELV circuits or those used only to facilitate assembling/disassembling (multipole connectors).

Plug/socket combinations that are rated at more than 16 A or that remain connected during normal service shall be of a retaining type to prevent unintended disconnection. Plug/socket combinations rated at 63 A or above shall be of an interlocked type with a switch, so that connection and disconnection is possible only when the switch is in the OFF position.

Where more than one plug/socket combination is used in the same electrical equipment, they shall be clearly identifiable. It is recommended that mechanical coding be used to prevent incorrect insertion.

Plug/socket combinations in accordance with **JIS C 8285-1** or of a type used for domestic applications shall not be used for control circuits.

**14.4.6 Dismantling for shipment** Where it is necessary that wiring be disconnected for shipment, terminals or plug/socket combinations shall be provided at the sectional points.

An interlocking of plug/socket combinations with a combined switch may be dispensed with, if the plug/socket combination is used only for erection and dismantling.

Such terminals shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage.

**14.4.7 Additional conductors** Consideration should be given to providing additional conductors for maintenance or repair. When spare conductors are provided, they shall be connected to spare terminals or isolated in such a manner as to prevent contact with live parts.

### 14.5 Ducts, connection boxes and other boxes

**14.5.1 General requirements** Ducts shall provide a minimum degree of protection of IP33 (see **JIS C 0920**).

All sharp edges, flash, burrs, rough surfaces, or projecting with which the insulation of the conductors may come in contact shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

Drain holes of 6 mm diameter thereabout are permitted in cable trunking systems, connection boxes, and other boxes used for wiring purposes that can be subject to accumulations of oil or moisture.

In order to prevent confusion of conduits with oil, air, or water piping, it is recommended that the conduits be either physically separated or suitably identified.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in such a manner so as to minimize the possibility of damage or wear. In areas where human passage is required, the ducts and cable trays shall be mounted to give at least the clearance specified in **12.5.1**.

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Ducts shall be provided only for mechanical protection (see **8.2.3** for requirements for connection to the protective bonding circuit).

Cable trays that are partially covered should not be considered to be ducts or cable trunking systems (see **14.5.6**), and the cables used shall be suitable for installation on cable trays (see **14.4.2**).

**14.5.2 Percentage fill of ducts** Consideration of the percentage fill of ducts should be based on the straightness and length of the duct and the flexibility of the conductors. It is recommended that the dimensions and arrangement of the ducts be such as to facilitate the insertion of the conductors and cables.

**14.5.3 Rigid metal conduits and fittings** Rigid metal conduits and fittings shall be of galvanized steel or of a corrosion-resistant material suitable for the conditions. The use of dissimilar metals in contact that can cause galvanic action should be avoided.

Conduits shall be securely held in place and supported at each end.

Fittings shall be compatible with the conduit and appropriate for the application. Fittings should be threaded unless structural difficulties prevent assembly. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

Conduit bends shall be made in such a manner that the conduit shall not be damaged, and the internal diameter of the conduit shall not be effectively reduced.

**14.5.4 Flexible metal conduits and fittings** Flexible metal conduits shall consist of flexible metal tubing or woven wire armor. It shall be suitable for the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

**14.5.5 Flexible non-metallic conduits and fittings** Flexible non-metallic conduits shall be resistant to kinking and shall have physical characteristics similar to those of the sheath of multiconductor cables.

The conduits shall be suitable for use in the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

**14.5.6 Cable trunking systems** Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the hoisting machine.

Covers shall be shaped to overlap the sides; gaskets shall be permitted. Covers shall be attached to cable trunking systems by hinges or chains and held closed by means of captive screws or other suitable fasteners. On horizontal cable trunking systems, the cover shall not be on the bottom.

Where the cable trunking system is furnished in sections, the joints between sections shall fit tightly but need not be gasketed.

The only openings permitted shall be those required for wiring or for drainage. Cable trunking systems shall not have opened but unused knock-outs.

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**14.5.7 Hoisting machine compartments and cable trunking systems** The use of compartments or cable trunking systems within a hoisting machine to enclose conductors shall be permitted provided the compartments or cable trunking systems are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to mechanical damage.

**14.5.8 Connection boxes and other boxes** Connection boxes and other boxes used for wiring purposes shall be readily accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the hoisting machine is intended to operate (see **12.3**). The construction shall be sufficient to protect against mechanical damage in normal use.

Those boxes shall not have opened but unused knockouts nor any other openings and shall be so constructed as to exclude materials such as dust, flyings, oil, and coolant.

**14.5.9 Motor connection boxes** Motor connection boxes shall enclose only connections to the motor and moor-mounted devices (e.g. brakes, temperature sensors, plugging switches, tachometer generators, speed detectors).

## 15 Electric motors and associated equipment

**15.1 General requirements** Electric motors should conform to the requirements of **JIS C 4034-1**.

These motors and associated equipment shall be protected from overcurrent protection, overload and overspeed according to **7.2**, **7.3** and **7.6** respectively.

As many controllers do not switch off the supply to a motor when it is at rest, care shall be taken to ensure compliance with the requirements of **5.3** to **5.5**, **7.5**, **7.6**, and **9.4**. Motor control equipment shall be located and mounted in accordance with clause **12**.

**15.2 Motor enclosures** It is recommended that motor enclosures be chosen from those included in **JIS C 4034-5**.

The degree of protection shall be at least IP23 (see **JIS C 0920**) for all motors. More stringent requirements may be needed depending on the application and the physical environment (see **4.4**). Motors incorporated as an integral part of the hoisting machine shall be so mounted that they are adequately protected from mechanical damage.

**15.3 Motor dimensions** As far as is practicable, the dimensions of motors shall conform to those given in **IEC 60072-1** and **IEC 60072-2**.

**15.4 Motor mounting and compartments** Each motor and its associated couplings, belts and pulleys, or chains, shall be so mounted that they are adequately protected and are easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor hold-down means can be removed and all terminal boxes are accessible.

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Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the limits of the insulation class (see **JIS C 4034-1**).

Where possible, motor compartments should be clean and dry, and when required, shall be ventilated directly to the exterior of the hoisting machine. The vents shall be such that ingress of swarf, dust, or water spray is at an acceptable level.

There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a conduit or pipe is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the conduit or pipe shall be sealed.

**15.5 Criteria for motor selection** The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environment conditions (see **4.4**). In this respect, the points that shall be considered include:

— type of motor;

— type of duty cycle (see **JIS C 4034-1**);

— fixed speed or variable speed operation, (and the consequent variable influence of the ventilation);

— mechanical vibration;

— type of converter for motor speed control (see **IEC 60146-1-1**);

— influence of the harmonic spectrum of the voltage and/or current feeding the motor (when it is supplied from a static converter) on the temperature rise;

— method of starting and the possible influence of the inrush current on the operation of other users. Taking also into account possible special considerations stipulated by the supply authority;

— variation of counter torque load with time and speed;

— influence of loads with large inertia;

— influence of constant torque or constant power operation;

— possible need of inductive reactors between motor and converter (when it is supplied from a static converter).

**15.6 Protective devices for mechanical brakes** Operation of the overload and overcurrent protective devices by mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated machine actuators.

NOTE : Associated machine actuators are those associated with the same motion, for example cable drums and long-travel drives.

**15.7 Electrically operated mechanical brakes** Where electrically operated mechanical brakes which are applied by removal of power are used, removal of power to motion drives shall result in removal of power to the associated brakes.

**Exception** : Operational braking in travel and slewing drives may use other methods of brake control.

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## 16 Accessories and lighting

**16.1 Accessories** Where the hoisting machine or its associated equipment is provided with socket-outlets that are to be used for accessory equipment (e.g. hand-held power tools, test equipment), the following apply:

— the socket-outlets should conform to **JIS C 8285-1**. Where that is not possible, they should be clearly marked with the voltage and current ratings;

— the continuity of the protective bonding circuit to the socket-outlet shall be ensured (exception see **6.4**);

— all unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with **7.2** and **7.3** separately from the protection of other circuits;

— where the power supply to the socket-outlet is not disconnected by the crane disconnector, the requirements of **5.3.8** apply.

### 16.2 Local lighting on the hoisting machine and for the equipment

**16.2.1 General** Connections to the protective bonding circuit shall be in accordance with **8.2.2**.

The ON-OFF switch shall not be incorporated in the lampholder or in the flexible connecting cords.

Stroboscopic effects from lights shall be avoided by the use of appropriate luminaires.

Where fixed lighting is provided in an enclosure, electromagnetic comparability shall be taken into account using the principles outlined in **4.4.2**.

**16.2.2 Supply** It is recommended that the nominal voltage of the local lighting circuit should not exceed 50 V between conductors. Where a higher voltage is used, that value shall not exceed 250 V between conductors.

Lighting circuits shall be supplied from one of the following sources (see also **7.2.6**). (Excepting that this does not apply to the case where fixed lighting is out of reach of operators during normal operation):

— a dedicated isolating transformer connected to the load side of the crane disconnector. Overcurrent protection shall be provided in the secondary circuit;

— a dedicated isolating transformer connected to the line side of the crane disconnector. That source shall be permitted for maintenance lighting circuits in control enclosures only. Overcurrent protection shall be provided in the secondary circuit (see also **5.3.8** and **14.1.3**);

— a hoisting machine circuit with dedicated overcurrent protection;

— an externally supplied lighting circuit (e.g. factory lighting supply). This shall be permitted in control enclosures only, and for the hoisting machine work light(s) where the total power rating is not more than 3 kW.

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**16.2.3 Protection** Local lighting circuits shall be protected in accordance with **7.2.6**.

**16.2.4 Lighting fittings** Adjustable lighting fittings shall be suitable for the physical environment.

The lampholders shall be as follows;

— in accordance with the relevant **JIS** or **IEC** publication;

— constructed with an insulating material protecting the lamp cap so as to prevent unintentional contact.

Reflectors shall be supported by a bracket and not by the lampholder.

**Exception** : Where fixed lighting is out of reach of operators during normal operation, the provisions of this subclause do not apply.

## 17 Marking, warning signs and reference designations

**17.1 General** The electrical equipment shall be marked with the supplier's name, trade mark, or other identifying symbol and, when required, with a certification mark.

Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

**17.2 Warning signs (live mark)** Enclosures that do not otherwise clearly show that they contain electrical devices shall be marked with live indication that is a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol **IEC 60417-2-5036**, the whole in accordance with sign B.3.6 of **JIS Z 9101**.

Graphical symbol **IEC-60417-2-5036**

The live mark shall be plainly visible on the enclosure door or cover.

The live mark may be omitted for:

— an enclosure equipped with a supply disconnecting and switching device;

— an operator-machine interface or control station;

— a single device with its own enclosure (e.g. position sensor).

**17.3 Functional identification** Control devices, visual indicators, and displays (particularly those related to safety) used in the man-machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the item. Such markings may be as agreed between the user and the supplier of the equipment (see annex A). Preference should be given to the use of standard symbols given in **IEC 60417-1** and **ISO 7000**.

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**17.4 Marking of control equipment** Control equipment shall be legibly and durably marked in a way that is plainly visible after the equipment is installed. Wherever possible, a nameplate giving the following information shall be attached to the enclosure:

— name or trade mark of supplier;

— certification mark when required;

— serial number of where applicable;

— rated voltage, number of phases and frequency (if a.c.), and full-load current for each supply (see **JIS C 1082**).

— short-circuit interrupting capacity of the machine overcurrent protective device where furnished as part of the equipment;

— the electrical diagram number(s) or the number of the index to the electrical drawing.

The full-load current shown on the nameplate shall be at least the combined full-load currents for all motors and other equipment that can be in operation at the same time under normal conditions of use. Where there are unusual loads or duty cycles, the thermal equivalent current (see annex B, **B.2**) shall be included in the full-load current specified on the nameplate.

For a hoisting machine with more than one motion drive, such nameplates maybe replaced by the relevant documentation.

**17.5 Reference designations** All enclosures, assemblies, control devices, and components shall be plainly identified with the same reference designation as shown in the technical documentation that shall be in accordance with **IEC 61346-1**.

Where size or location preclude the use of an individual reference designation, group reference designation shall be used.

**Exception** : The requirements of this subclause may not apply to hoisting machines on which the equipment comprises only a single motor, motor-controller, push-button station(s), and worklight(s).

## 18 Technical documentation

**18.1 General** The information necessary for installation, operation, and maintenance of the electrical equipment of a hoisting machine shall be supplied in the form of drawings, diagrams, charts, tables, and instructions. The information shall be in an agreed language (see annex A).

The information provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be contained in one document, provided that the document shows all the devices of the electrical equipment and enables the connections to the supply network to be made.

The supplier shall ensure that the technical documentation specified in this clause is provided with each hoisting machine.

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**18.2 Information to be provided** The information provided with the electrical equipment shall include:

a) a clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies);

b) electrical supply(ies) requirements;

c) information on the physical environment (e.g. lighting, vibration, noise levels, atmospheric contaminants) where appropriate;

d) overview (block) diagram(s) where appropriate;

e) circuit diagram(s);

f) information (where appropriate) on:

   1) programming;

   2) sequence of operation(s);

   3) frequency of inspection;

   4) frequency and method of functional testing;

   5) guidance on the adjustment, maintenance, and repair, particularly of the protective devices and circuits; and

   6) parts list and recommended spare parts list.

g) a description (including interconnection diagrams) of the safeguards, interlocking functions, and interlocking of guards for potentially hazardous motions, particularly for hoisting machines operating in a co-ordinated manner;

h) a description of the safeguarding and of the means provided where it is necessary to suspend the safeguarding (e.g. for manual programming, program verification), (see **9.2.4**).

**18.3 Requirements applicable to all documentation** The documents shall be prepared in accordance with requirements of **18.4** to **18.10** and the relevant parts of **JIS C 1082-1**.

The reference designation system shall be in accordance with **IEC 61346-1**.

For referencing of the different documents, the supplier shall select one of the following methods:

— each of the documents shall carry as a cross-reference the document numbers and titles of all other documents belonging to the electrical equipment;

— all documents shall be listed with document numbers and titles in a drawing or document list.

The first method shall be used only where the documentation consists of a small number of documents (e.g. less than five).

**18.4 Basic information** The technical documentation shall contain, as a minimum, information on the following:

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— normal operating conditions of the electrical equipment including the expected conditions of the electrical supply, and where appropriate, the physical environment;

— handling, transportation and storage;

— inappropriate use(s) of the equipment.

That information may be presented as a separate document or as part of the installation or operation documentation.

The documentation should also contain, where appropriate, information regarding load currents, peak starting currents and permitted voltage drops. That information should be contained in either the system or circuit diagram(s)

**18.5 Installation diagram** The installation diagram shall give all information necessary for the preliminary work of setting up the hoisting machine. In complex cases, it may be necessary to refer to the assembly drawings for details.

The recommended position, type, and cross-sectional areas of the supply cables to be installed on site shall be clearly indicated.

The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply conductors to the electrical equipment of the hoisting machine shall be stated (see **7.2.2**).

Where necessary, the size, purpose, and location of any ducts in the foundation that are to be provided by the user shall be detailed (see annex A).

The size, type, and purpose of ducts, cable trays, or cable supports between the hoisting machine and the associated equipment that are to be provided by the user shall be detailed (see annex A).

Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment.

NOTE 1 Examples of installation diagram can be found in **JIS C 1082-4**.

In addition, where it is appropriate an interconnection diagram or table shall be provided. That diagram or table shall give full information about all external connections. Where the electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall indicate the modifications or interconnections required for the use of each supply.

NOTE 2 Examples of interconnection diagrams/tables can be found in **JIS C 1082-3**.

**18.6 Black (system) diagrams and function diagrams** Where it is necessary to facilitate the understanding of the principles of operation, a block (system) diagram shall be provided. A block (system) diagram symbolically represents the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections.

NOTE 1 Examples of block diagrams can be found in **JIS C 1082-1**, clause **2**.

Function diagrams may be used as either part of, or in addition to, the black (system) diagram.

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NOTE 2 Examples of function diagrams can be found in **JIS C 1082-1**, clause **2** and **JIS C 1082-2**, clause **4**.

**18.7 Circuit diagrams** Where a block (system) diagram does not sufficiently detail the elements of the electrical equipment, a circuit diagram(s) shall be furnished. Those diagrams shall show the electrical circuits on the hoisting machine and its associated electrical equipment. Any graphical symbol not shown in **JIS C 0617-1** to **-13** shall be separately shown and described on the diagrams or supporting documents. The symbols and identification of components and devices shall be consistent throughout all documents and on the hoisting machine.

NOTE : Examples of circuit diagrams can be found in **JIS C 1082-1**.

Where appropriate, a diagram showing the terminals for interface connections shall be provided. That diagram may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown.

Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (e.g. electricity, air, water, lubricant) and with the hoisting machine and its electrical equipment in the normal starting condition.

Conductors shall be identified in accordance with **14.2**.

Circuits shall be shown in such a way as to facilitate the understanding of their function as well as maintenance and fault location. Characteristics relating to the function of the control devices and components which are not evident from their symbolic representation shall be included on the diagrams adjacent to the symbol or referenced to a footnote.

**18.8 Operating manual** The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the equipment. Particular attention should be given to the safety measures provided, and to the improper methods of operation that are anticipated.

Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, programme verification, and additional safety procedures (where required) shall be provided.

**18.9 Maintenance manual** The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair. Recommendations on maintenance/service records should be part of that manual. Where methods for the verification of proper operation are provided (e.g. software testing programmes), the use of those methods shall be detailed.

**18.10 Parts list** The parts list shall comprise, as a minimum, information necessary for ordering spare or replacement parts (e.g. components, devices, software, test equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment.

The parts list shall show for each item:

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— the reference designation used in the documentation;

— its type designation;

— the supplier and alternative sources where available;

— its general characteristics, where appropriate.

## 19 Testing and verification

**19.1 General** This Standard gives general requirements for the electrical equipment of hoisting machines. The relevant tests for a particular hoisting machine type will be given in the dedicated product standard. Where there is no dedicated product standard for a standard hoisting machine, the following tests shall be carried out on a sample of the hoisting machine:

— verification that the electrical equipment is in compliance with the technical documentation;

— continuity of the protective bonding circuit (see **19.2**);

— insulation resistance tests (see **19.3**);

— functional tests (see **19.4**).

These tests shall be carried out on every hoisting machine that is assembled on site.

When the electrical equipment of a hoisting machine is modified, the requirements stated in **19.5** shall apply.

**19.2 Continuity of the protective bonding circuit** When the hoisting machine is installed and the electrical connections are complete, including those to the power supply, the continuity of the protective bonding circuit can be verified by a loop impedance test in accordance with **JIS C 0364-6-61**, **612.6.3**.

For small hoisting machines, pre-manufactured hoisting machines or parts of hoisting machines with protective bonding loops not exceeding approximately 30 m, and where the hoisting machine cannot be connected to the power supply for the loop impedance test, the following method may be appropriate:

— verify the continuity of the protective bonding circuit by injecting a current of at least 10 A at 50 Hz or 60 Hz derived from a PELV source. The tests are to be made between the PE terminal (see **5.2**) and relevant points that are part of the protected bonding circuit;

— the measured voltage between the PE terminal (see **5.2**) and the points of test is not to exceed the values given in table 9 (see **8.2.2**).

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**Table 9 Verification of continuity of the protective bonding circuit**

| Minimum effective protective conductor cross-sectional area of the branch under test ($mm^2$) | Maximum measured voltage drop (values are given for a test current of 10 A) (V) |
|---|---|
| 1.0 | 3.3 |
| 1.5 | 2.6 |
| 2.5 | 1.9 |
| 4.0 | 1.4 |
| >6.0 | 1.0 |

**19.3 Insulation resistance tests** The insulation resistance measured at 500 V d.c. between the power circuit conductors and the protective bonding circuit shall not be less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

**Exceptions** 1 For certain parts of electrical equipment, incorporating for example busbars, collector wire or collector bar systems or slip-ring assemblies, a lower minimum value shall permitted, but that value is not to be less than 50 kΩ.

2 For the insulation resistance test for electric over-hoisting prevent device of crane, **JIS C 8201-4-1** shall apply.

3 Control devices comprising electron component such as converter should be tested according to the manufacturer's documentation of the device.

**19.4 Functional tests** The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding.

**19.5 Retesting** Where a portion of the hoisting machine and its associated equipment is changed or modified, that porion shall be reverified and retested, as is appropriate (see **19.1**).

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Related standards:

JIS C 3664 : 1998 *Conductors of insulated cables*

JIS C 8211 : 1999 *Circuit-breakers for overcurrent protection for household and similar installation*

JCS 168 : 1995 *Calculation of the current rating of power cables for rated voltages up to and including 33 kV—Part 1 : Formula and constant* (The Japanese Electric Wire & Cable Maker's Association)

EN 50081 : 1993 *Electromagnetic compatibility—Generic emission standard*

EN 50082-2 : 1992 *Electromagnetic compatibility—Generic immunity standard—Part 2 : Industrial environment*

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## Annex A (informative)

## Inquiry form for the electrical equipment of hoisting machines

This annex A (informative) is to supplement the matters related to the text and not to constitute provisions of this Standard.

It is recommended that the following information is provided by the intended user of the equipment. It facilitates an agreement between the user and supplier on basic conditions and additional user requirements to ensure proper design, application and utilization of the electrical equipment of the hoisting machine (see the text **4.1**).

Name of manufacturer/supplier .....

Name of end user .....

Tender/Order No ..... Date .....

Type of hoisting machine/serial number .....

1. Are there to be modifications as allowed for within this Standard? YES ____ NO ____

**Operating conditions—Special requirements** (see the text **4.4**)

2. Ambient temperature range .....
3. Humidity range .....
4. Altitude .....
5. Environmental (e.g. corrosive atmospheres, particulate matter, EMC) .....
6. Radiation .....
7. Vibration, shock .....
8. Special installation and operation requirements (e.g. flame retardant requirements for cables and conductors)

   .....

**Power supply(ies) and related conditions** (see the text **4.3**)

9. Anticipated voltage fluctuations (if more than ± 10 %) .....
10. Anticipated frequency fluctuations (if more than in the text **4.3.2**)

    Specification of short-term value .....
11. Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements .....
12. Indicate for each source of electrical supply required:

    Nominal voltage (V) ..... AC ..... DC .....

    If a.c., number of phases ..... Frequency ..... Hz

    Prospective short circuit current at the point of supply to the hoisting machine ..... kA r.m.s. (see also question 15)

    Fluctuations outside values given in **4.3.2** .....

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13. Type of power supply earthing (see **JIS C 0364-3**):

    — TN (system with one point directly earthed, with a protective conductor (PE) connected directly to that point).....

    — TT (system with one point directly earthed but the protective conductor (PE) not connected to that earth point of the system) .....

    — IT (system that is not directly earthed).....

14. Is the electrical equipment to be connected to a neutral (N) supply conductor? (see the text **5.1**)

    YES _____ NO _____

15. Does the user or the supplier provide the overcurrent protection of the supply conductors? (see the text **7.2.2**)

    YES _____ NO _____

    Type and rating of overcurrent protective devices .....

16. Supply disconnecting and switching device

    — Is the disconnection of the neutral (N) conductor required? YES _____ NO _____

    — Is a link for the neutral (N) permissible? YES _____ NO _____

    — Type of disconnecting device to be provided.....

17. Limit of power up to which three-phase a.c. motors may be started directly across the incoming supply lines? ..... kW

18. May the number of motor overload detection devices be reduced? (see the text **7.3**)

    YES _____ NO _____

19. Where the hoisting machine is equipped with local lighting:

    — Highest permissible voltage ..... V

    — If lighting circuit voltage is not obtained directly from the power supply, state preferred voltage? ..... V

**Other considerations**

20. Functional identification (see the text **17.3**) .....

21. Inscriptions/special markings

    — Mark of certification YES _____ NO _____ If YES, which one? _____

    — On electrical equipment?..... In which language? .....

22. Technical documentation (see the text **18.1**)

    On what media? ..... In which language? .....

23. Size, location, and purpose of ducts, open cable trays, or cable supports to be provided by the user? (see the text **18.5**) (additional sheets to be provided where necessary)

24. For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?

    — Skilled persons.....

    — Instructed persons.....

25. Are locks with removable keys to be provided for fastening doors or covers (see the text **6.2.2**)? .....

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26. If "two-hand control" is to be provided, state the type: .....

    Where it is type III, state the time limit (0.5 s maximum) within which each pair of push-buttons are to be operated .....

27. Indicate if special limitations on the size or weight affect the transport of a particular hoisting machine or controlgear assemblies to the installation site:

    — maximum dimensions .....

    — maximum weight .....

28. What is the mean number of transport cycles per hour? .....

    NOTE : A transport cycle comprises all operations which begin with the hoisting of a load and end when the hoisting machine is ready for hoisting the next load.

    For what length of time is it expected that the hoisting machine will be operated at this rate with subsequent pause? ..... h

29. For cable-less control systems, specify the time delay before automatic hoisting machine shutdown is initiated in the absence of a valid signal (see the text **9.2.7.3**) ..... s

30 Do you need a specific method of conductor identification to be used for the conductors referred to in the text **14.2.4**?

    YES ..... NO ..... Type .....

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## Annex B (informative)

## Current-carrying capacity and overcurrent protection of conductors and cables in the electrical equipment of machines

This annex B (informative) is to supplement the matters related to the text and not to constitute the provisions of this Standard.

The purpose of this annex is to provide additional information on the selection of conductor sizes where the conditions given for table 5 (see the text clause **13**) have to be modified (see NOTES to table 5 of the text).

### B.1 General operating conditions

**B.1.1 Ambient air temperature** The current carrying capacity for PVC insulated conductors given in the text table 5 is related to an ambient air temperature of +40 °C. For other ambient air temperatures, the installer has to correct the values using the factors given in annex B table 1.

**Annex B Table 1 Correction factors**

| Ambient air temperature °C | Correction factor |
|---|---|
| 30 | 1.15 |
| 35 | 1.08 |
| 40 | 1.00 |
| 45 | 0.91 |
| 50 | 0.82 |
| 55 | 0.71 |
| 60 | 0.58 |

NOTE: The correction factors are derived from **JIS C 0364-5-523**, table 52-D1.

**B.1.2 Methods of installation** In machines, the methods of conductor and cable installation between enclosures and individual items of the equipment shown in annex B figure 1 are assumed to be typical (the method class symbols used are in accordance with **JIS C 0364-5-523**):

— Method B1: using conduits (the text **3.8**) and cable trunking systems (the text **3.6**) for holding and protecting conductors (single-core cables);

— Method B2: same as B1 but used for multicore cables;

— Method C: cables installed on walls without ducts or conduits;

— Method E: cables in horizontal or vertical open cable trays (the text **3.5**).

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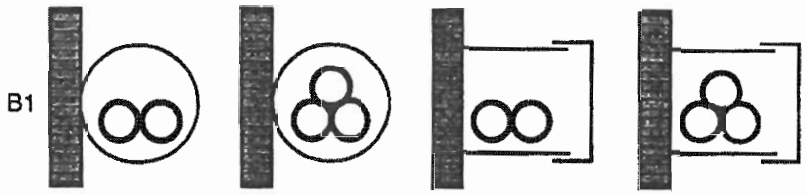
**B.1.3 Grouping** The values of the current carrying capacity of the text **13.4** and table 5 are based on:

— one loaded three-phase a.c. cable system for cross-sectional areas 0.75 mm² and greater;

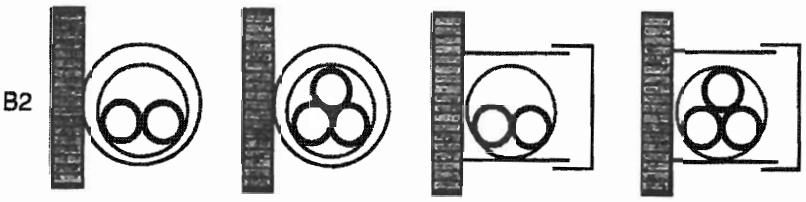
— one loaded pair (of two conductors) for a d.c. control circuit for cross-sectional areas between 0.2 mm² and 0.75 mm².

Where more loaded cables/pairs are installed, derate the values of the text table 5 in accordance with annex B tables 2 or 3.

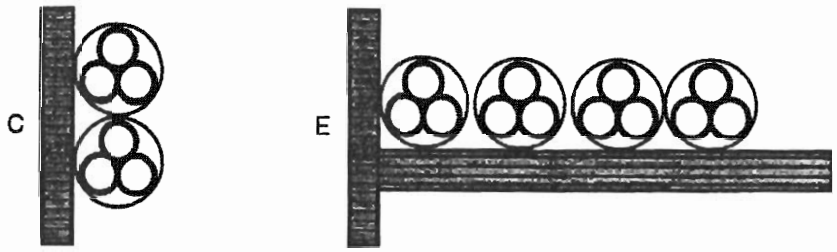
Conductors of control circuits normally need no reduction.




Conductors in conduit and cable trunking systems




Cable in conduit and cable trunking systems




Cables on walls and open cable trays

**Annex B Figure 1 Methods of conductors and cable installation**

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